



# ***LARGE ENGINE CATALOG***

***For Varifuel Carburetors***

***Includes Information on Maintenance, Adjustments  
and Fuel Pressure Regulators***



# INDEX

I. <b>SAFETY</b> .....	<b>1</b>
II. <b>Carburetor/Mixer Overview</b> .....	<b>3</b>
A. Air Valve Mixer Theory of Operation .....	3
B. Venturi Mixer Theory of Operation.....	3
C. Selecting the Correct Carburetor/Mixer .....	5
D. Formulas.....	6
III. <b>VARIFUEL Carburetor/Mixer Descriptions &amp; Specifications</b> .....	<b>9</b>
A. Model 400VF3 .....	11
B. Model 600VF3 .....	24
C. Model 600VF3D .....	39
IV. <b>VARIFUEL Carburetor Installation</b> .....	<b>49</b>
A. Model 400VF3 .....	49
B. Model 600VF3 .....	55
C. Model 600VF3D .....	63
V. <b>VARIFUEL Carburetor Adjusting &amp; Maintenance</b> .....	<b>69</b>
A. Adjusting the VARIFUEL Carburetor .....	69
B. Lean Burn Operation .....	70
C. Changing the Gas Valve/Jet Kit .....	72
D. Changing the Power Valve & Power Jet .....	80
E. Recommended Service Parts .....	83
VI. <b>Pressure Regulators</b> .....	<b>87</b>
A. Introduction .....	87
B. IMPCO IMP Regulators .....	91
C. Regulator Installation .....	95
D. Adjusting Primary and Sub-Regulators.....	97
VII. <b>General Information</b> .....	<b>100</b>
A. Gaseous Fuel Types.....	100
B. Gaseous Fuel Benefits .....	100
C. Pressure Conversion Chart.....	101
D. Crankcase Oil Requirements .....	101
E. Effects of Temperature on Power Output .....	102
F. Effects of Altitude on Power Output.....	103
G. Effects of Altitude on Manifold Depression (Vacuum).....	104
H. Air Displacement by Fuel (& the Effect on Power Output) .....	105
I. Air- Terms and Measurement .....	106
VIII. <b>VARIFUEL Carburetor Application by Engine Manufacturer</b> .....	<b>110</b>
IX. <b>Large Engine Application Information Worksheet</b> .....	<b>113</b>
X. <b>Test Equipment/Tools</b> .....	<b>114</b>
XI. <b>Conversion Factors</b> .....	<b>117</b>
XII. <b>Approximate Heat Content of Petroleum Products</b> .....	<b>131</b>
XIII. <b>Correction Table for Altitudes</b> .....	<b>132</b>



# **SAFETY**

## **READ BEFORE PERFORMING ANY SERVICE, MAINTANENCE OR REPAIR ON THE FUEL SYSTEM**

There are safety regulations and standards that must be followed when installing or servicing gaseous fuel equipment on large engines. It is highly recommended you obtain and read the following National Fire Protection Association (NFPA) guidelines:

- NFPA #37- Combustion Engines
- NFPA #52- CNG Vehicular Fuel Systems
- NFPA #54- National Fuel Gas Codes
- NFPA #58- LP Gas Storage
- NFPA #59- LP Gas Utility Plants
- NFPA #59A- LN Gas Storage and Handling

To order these documents, contact the National Fire Protection Agency at (800) 344-3555 or go to [www.nfpa.org](http://www.nfpa.org), expand the *Codes and Standards* menu, and click on *Document List and Code Cycle Information* to order online.

There are state standards and regulations enforced by the state fire marshal in most states. In Texas, the Texas State Railroad Commission sets standards.

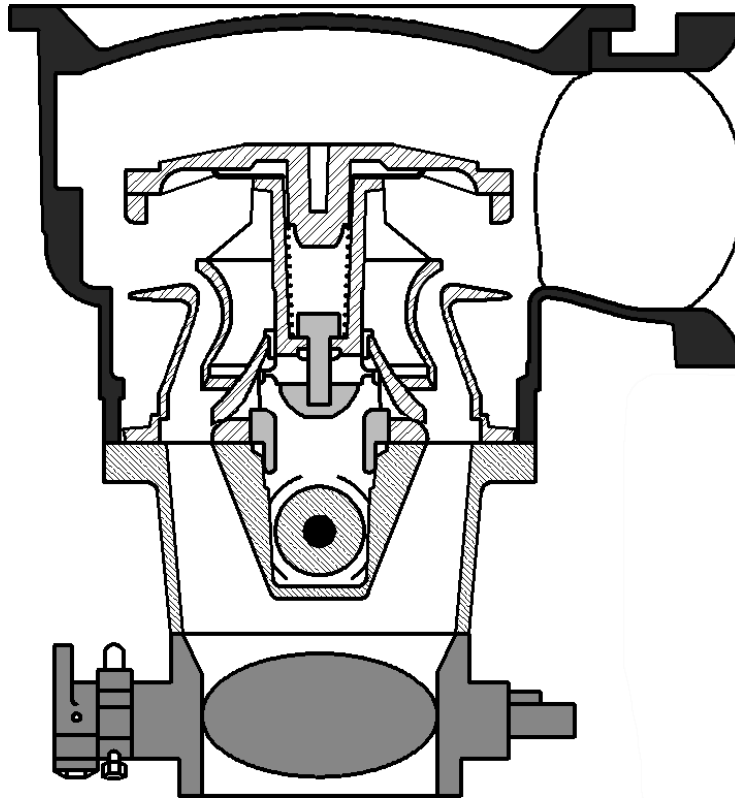
There may be other local standards set by counties, cities and municipalities. Be sure to consult all regulatory agencies to assure adherence to all standards in enforcement. Safety in the workplace is everyone's responsibility. Regardless of the type work you do, it is very important that you pay attention to what you are doing for your safety and the safety of those around you.

The following points are things to keep in mind when working on internal combustion engines and gaseous fuel systems:

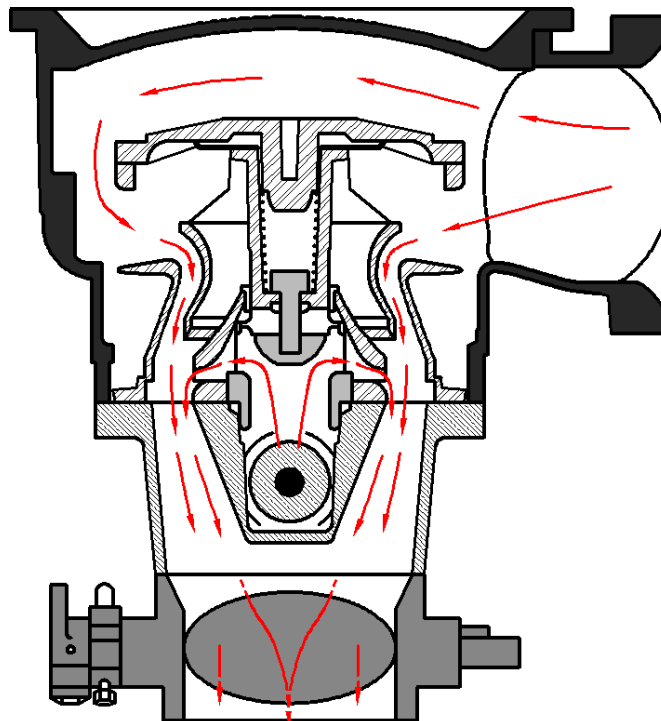
- Before working on any fuel system, study the NFPA standard for the fuel in use.
- Before working on any fuel system, read and understand all manufacturers' recommended procedures.
- Before working on any fuel system, make sure you have local code approved safety goggles, face shields, gloves and clothing.
- Before working on any fuel system, make sure there is adequate ventilation.
- Before working on any fuel system, turn OFF the fuel system supply valve and slowly bleed the fuel from all lines before working on the fuel system or engine.
- After working on any fuel system, perform a leak test before turning on the fuel valve.

Remember:

- LPG is heavier than air and will sink to the lowest level. Avoid areas near flow drains or lubrication pits where escaped fuel can collect and all sources of ignition.
- Natural gas is lighter than air and will rise to the highest point. Avoid areas near overhead heaters and all other sources of ignition.



*Throttle Closed*



*Throttle Open*

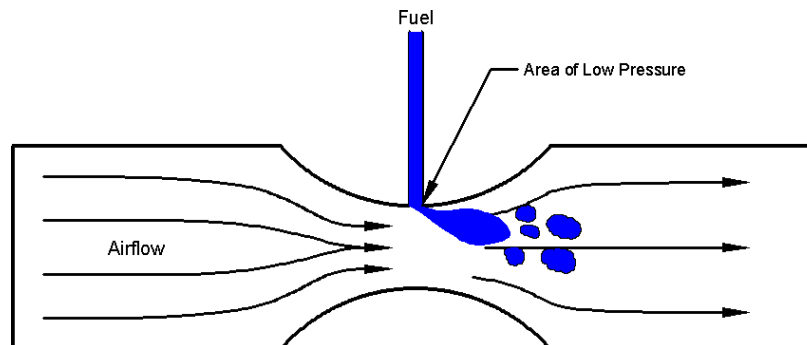
# Carburetor/Mixer Overview

## A. Air Valve Mixer Theory of Operation:

The air/gas valve mixer is mounted in the intake air stream above the throttle plate and is designed to create a slight pressure drop (negative pressure) as air is drawn into the engine. This negative pressure signal is communicated to the upper side of the diaphragm through passages in the air/gas valve assembly. Atmospheric pressure acting on the under side of the diaphragm forces it upward against the metering spring. The metering spring is calibrated to generate about negative 6 inches (-6") of water (H<sub>2</sub>O) column at idle and up to about -14" (H<sub>2</sub>O) column at wide open throttle. The amount of negative pressure generated is a direct result of throttle position and the amount of air flowing through the mixer. As the diaphragm rises, it lifts the tapered gas metering valve off of its seat and exposes the fuel outlet to the negative pressure generated within the mixer. This allows the negative pressure signal to travel to the secondary chamber of the pressure regulator and act upon the under side of the secondary diaphragm. Atmospheric pressure above the diaphragm forces it against the secondary metering spring opening the secondary valve allowing fuel to flow into the air/gas valve mixer. The tapered shape of the gas-metering valve is designed to maintain the correct air/fuel ratio over the entire operating range of the engine.

## B. Venturi Mixer Theory of Operation:

The venturi mixer is a very simple design with no moving parts. It is placed in the intake air stream between the air cleaner and the throttle body. The design of the venturi creates a slight negative pressure as air is drawn through it. This negative pressure is used to draw fuel from the regulator into the intake air stream.



***Venturi Mixer During Operation***

Engine Airflow requirement listed on the chart are in Cubic Feet per Minute (CFM) at 85% volumetric efficiency for 4-cycle engine (double the CFM for 2-cycle engines).

To convert liters (L) to CID, multiply the Liter Displacement by 61.02.

Example :  $2.0 \times 61.02 = 122.04$  CID



### C. Selecting the Correct Carburetor/Mixer:

1) Airflow Capacities:

It is important to correctly size the airflow capacity of the IMPCO VARIFUEL conversion carburetor/mixer to the engine airflow requirement. If the carburetor/mixer specified is too small, then the power output of the engine will be limited. Conversely, a carburetor that is too large for an engine will create problems with idle stability and inconsistent fuel mixtures, especially at low speed. As a general rule, the airflow capacity of the carburetor should be reasonably close to the airflow requirement of the engine. If a carburetor is not available that matches the engine's airflow requirements, then it is usually recommended to over-carburetor than under-carburetor (round the CID up). In general, under carburetor for maximum efficiency, and over-carburetor for maximum power. Consider these options when determining your Carburetor/Mixer needs.

2) Determining Estimated Engine Airflow Requirements with the Chart (on Facing Page). The chart gives engine airflow requirements for some common engine displacements at various maximum rpms.

To find the estimated airflow requirement for the engine you are converting:

- Locate the engine's displacement (in CID) and maximum rpm on the chart.
- Draw a line across from the CID and down from the rpm.
- Where the lines cross is the airflow requirements (in CFM) for that engine.

Example:

An industrial stationary generator with a 4-cycle, naturally aspirated 817 CID engine and a redline of 2,000 rpm: The estimated required airflow for this engine is 418 CFM (rounding the CID up to 850).

3) After the engine's airflow requirements are determined, the proper carburetor/mixer may be selected. The following table gives the horsepower and maximum airflow ratings for the VARIFUEL carburetors.

Model	Rated Horsepower (Naturally Aspirated)	Cubic Feet/Minute (CFM)	Cubic Feet/Hour (CFH)
400VF3	320	500	30,000
600VF3	540	960	57,800
600DVF3	1,000	1,600	96,000

***VARIFUEL Mixer/Carburetor Engine Applications  
Wide Open Throttle @ 2" Manifold Depression***

## Formulas:

- 4) The first thing that needs to be done before any calculations can be performed, is to determine the engine's displacement in cubic inches (Cubic Inch Displacement or CID) and its maximum rpm.
- Determine the engine's CID from the identification plate or from the user's manual. If the displacement is in liters (L), then convert it to CID by multiplying by 61.02. If it is in cubic centimeters (CC), then convert it by multiplying by 0.06102.
  - Determine the engine's maximum rpm either by locating it on the tachometer (if equipped) or from the user's manual.

- 5) For Naturally Aspirated Engines:

$$\text{CID} \times \text{RPM} \div 1728 \div 2 \times 0.85 = \text{Airflow Requirement (CFM)}$$

The engine airflow requirements determined by this equation are for 4-cycle engines with 85% volumetric efficiency. For 2-cycle engines, omit the division by 2.

- Multiply the CID times the rpm.
- Divide the result by 1728 to convert the cubic inches per minute (CIM) to CFM.
- Divide this by 2 for a 4-cycle engine (a 4-cycle engine only has an intake cycle every other revolution). Omit this step if engine is a 2-cycle.
- Multiply by 0.85 (85% volumetric efficiency) to get the engine's airflow requirement.

Example:

817 CID, 4-cycle carbureted engine with a maximum rpm of 2,000:  
 $817 \times 2000 \div 1728 \div 2 \times 0.85 = 402 \text{ CFM}$

- 3) Turbocharged Engines (with mixer upstream of turbocharger):

Turbocharged engines supply an additional boost in pressure over a naturally aspirated engine. This pressure must be calculated into the equation. To accomplish this:

- Determine the boost pressure of the turbocharger in Pounds per Square Inch (PSI).
- Determine the % increase in supplied air pressure.
- The following equation is performed to calculate the percentage (%) increase in supplied air pressure, including atmospheric pressure (at sea level is 14.7 PSI):

$$1 + ((\text{boost pressure in PSI}) \div 14.7)$$

$$\text{CID} \times \text{RPM} \div 1728 \div 2 \times 0.85 \times (\% \text{ available pressure increase}) = \text{CFM}$$

Example:

817 CID, 4-cycle turbocharged engine with boost pressure of 6 PSI and a maximum rpm of 2,000:

$$817 \times 2000 \div 1728 \div 2 \times 0.85 \times (1 + (6 \div 14.7)) =$$
$$817 \times 2000 \div 1728 \div 2 \times 0.85 \times 1.20 = 567 \text{ CFM}$$





**VARIFUEL 400VF3 Carburetor**

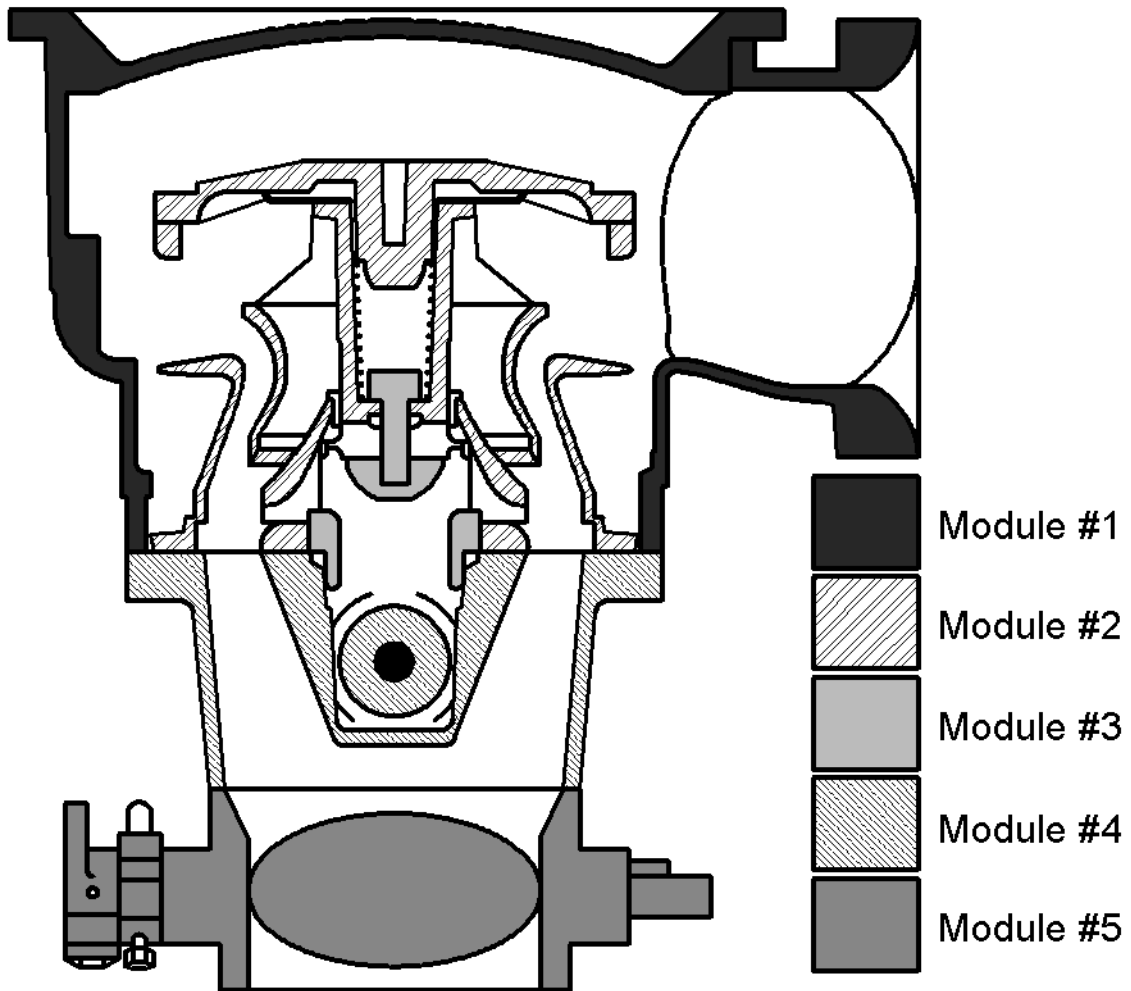
# VARIFUEL Carburetor Descriptions & Specifications

## Model 400VF3 Specifications

Fuel Type <sup>(1)</sup> .....	Propane & LPG (50/50 Propane/Butane) Natural Gas (85%+ Methane) Digester Gas (56-72% Methane) <sup>(2)</sup> Landfill Gas (45-56% Methane) <sup>(2)</sup>
Operating Pressures:	
Gas Inlet, Normal .....	5" H <sub>2</sub> O over Air Inlet (idle setting)
Air Inlet, Maximum .....	75 PSI
Backfire, Peak .....	200 PSI
Airflow Capacity .....	500 CFM @ 2" HG Depression (T2-7 @ WOT)
Horsepower Rating .....	320 BHP (Naturally Aspirated)
Air/Fuel Ratios .....	See Gas Valve Chart on page 31
Air/Fuel Adjustments:	
Low Speed/Load .....	Regulator Pressure (External to Carburetor)
High Load.....	Power Screw (10+ Turns)
Temperature Limits:	
Max. Operating.....	250° F
Max. Soakback.....	320° F
Materials:	
Air Valve body (BB1-66).....	Aluminum (Hard Anodized)
Air Valve (V1-16).....	Aluminum (Hard Anodized)
Gas Body (B1-67) .....	Aluminum (Hard Anodized)
Air Valve Cover (C1-30).....	Aluminum (Hard Anodized)
Inlet Housing (A2-70 or A2-69) .....	Aluminum (Hard Anodized)
Throttle Body (T2-7 or T2-8) .....	Aluminum (Hard Anodized)
Diaphragm (D1-25) .....	Silicone over Fiberglass
Guide Bushings.....	PPS Plastic, Glass and PTFE-filled
Gas Valve.....	Aluminum (Hard Anodized)
Gas Jet.....	Aluminum (Hard Anodized); Stainless Steel (optional)
Power Valve .....	High Carbon Steel
O-ring Seals .....	Buna N; Fluorocarbon optional
Fasteners & Power Screw.....	Carbon Steel, Zinc plated and baked
Springs.....	High Carbon Steel, Zinc plated and baked
Lubrication .....	None Required
Safety Certification.....	N/A (Engine User/Producer Responsibility)
Emissions Certification .....	N/A (Engine User/Producer Responsibility)
Weight 7.55 lbs (w/AT2-7 Throttle Body)	

<sup>(1)</sup>Each fuel requires a unique gas valve and jet combination.

<sup>(2)</sup>Requires J1-48 oversize power jet.



**400VF3 Modules**

## A. Model 400VF3:

The IMPCO 400 VARIFUEL (400VF3) is a gaseous fuel carburetor of the concentric flow, air valve type. It is designed to be a direct replacement for the IMPCO 200D carburetor. A precision gas metering valve is attached to the air valve. The air valve (and gas valve) motion is linear in relation to volumetric flow. The air/fuel ratio is controlled by the adjustable power valve, shape of the gas metering valve, and the pressure from the gas regulator. The 400VF3 has anti-wear guide bushings for the air valve assembly.

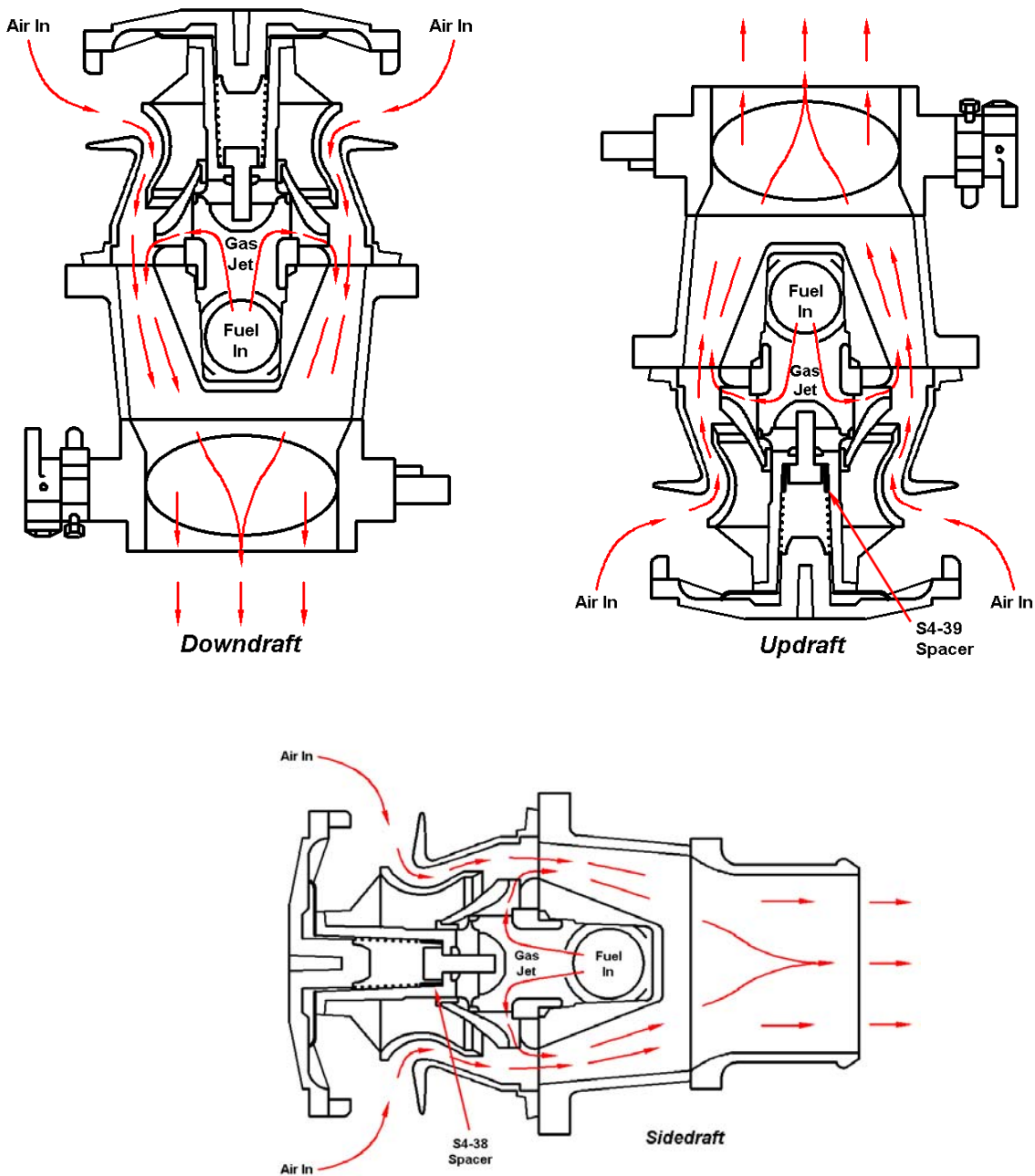
The 400 VARIFUEL is comprised of 5 modular elements (illustration on facing page):

- 1) Air Inlet Module (Air Horn)
- 2) Mixer Module
- 3) Gas Valve/Jet Module
- 4) Gas Inlet Module
- 5) Mixture Outlet Module (Throttle Body)

A complete carburetor includes all five modules. Deletion of either the Air Inlet or Mixture Outlet Module yields a *mixer assembly*. (See Ordering Information for part numbers.)

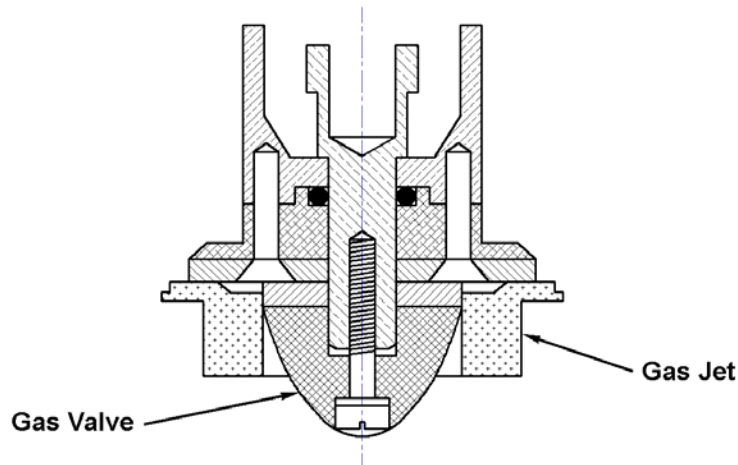
The attachment of the Air Inlet Module to the Gas Inlet Module uses a square bolt pattern, allowing four position options for the air inlet on the 90° inlet housing (part # AA2-70). For in-line flow applications, a unique module is available; part # AA2-69. Both are designed for a 4.0" diameter inlet hose.

Starting is largely controlled by the initial motion of the air valve, dictated by the Air Valve Vacuum (AVV) generated downstream of the mixer. The spring load and weight of the air valve/diaphragm assembly determines this motion. Interchangeable air valve spring spacers address updraft or sidedraft installations.

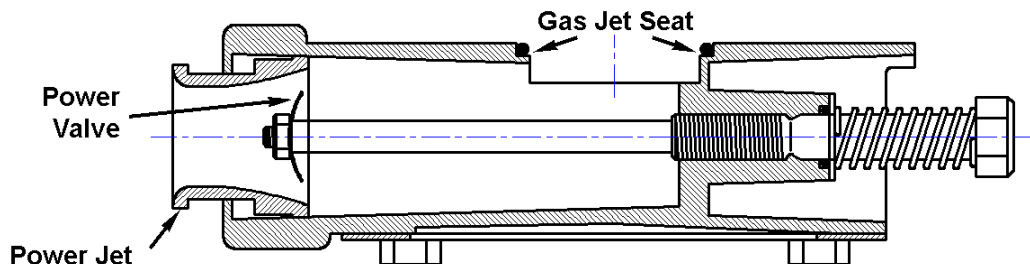




The gas valve and matching jet are sized for the gas to be used. Several jet sizes are available to adapt to fuels from propane to landfill gas. Gas valves are shaped to provide A/F versus flow characteristics defined by the customer. The gas valve shape is most crucial in the low flow (starting and light load) operating conditions.



The mixture adjustment power valve is located in the Gas Inlet Module. The power valve (attached to the mixture screw) is positioned within the power jet ID to provide an adjustable restriction to gas flow. The power valve has little influence during starting or under light loads. Two versions of the Gas Inlet Module are available to address the widely varying energy densities of fuels used in stationary gaseous fueled engines such as digester, or landfill gases. The attachment of the Gas Inlet Module also uses a square bolt pattern, allowing four position options for the gas inlet piping.



Two throttle bore sizes are available:  $\varnothing 2.50"$  and  $\varnothing 3.00"$ . Governor stability can be a problem if too large a throttle is used. A variety of adapters are available to mount the 400VF3 upstream of a turbocharger, remote from the throttle body. Also, an adapter is available to mount 400 VARIFUEL mixers on 600 VARIFUEL gas inlet modules (A3-128). This can save valuable engineering time when developing low speed options.

## 400VF3 ACCESSORIES & OPTIONS

### IMPCO 400VF3 VARIFUEL Gas Valve Options:

The 400VF3 VARIFUEL is designed to operate with a wide variety of fuels. From high energy propane/butane mixes down to 420 BTU/ft<sup>3</sup> landfill/digester gases, the 400VF3 can mix them in a manageable manner. To do this, four gas metering jet sizes were developed with IDs of: Ø0.625", Ø0.750", Ø0.900" and Ø1.080" (these jets are completely interchangeable). The two largest jets are CNC machined from stainless steel to operate in the often corrosive environments of digester and landfill gases.

Six basic gas valves are available for specific fuels and emissions control strategies. These valves are easily interchangeable with a flat blade screwdriver. For all 400VF3 gas valves, the gas inlet pressure should be set at 5-6" H<sub>2</sub>O column.

NOTE: Gas valves for specific OEM applications are available. Contact your local IMPCO distributor for more information.

### Natural Gas (NG) Non-emissions, Stoichiometric ( $\lambda=1.0$ )

V2-77 gas valve is used with J1-45 gas jet. The NG conversion kit can be purchased under part number CKV2-77. A good initial setting for the power screw is 6 turns from full lean (all the way in). The A/F can be set from lean to stoichiometric with the power screw for economic operation. Partial throttle operation on 100 to 250 HP engines will also be slightly lean.

V2-77 can also be used for propane operation with the IMPCO EB converter. The EB operates at -1.5" H<sub>2</sub>O carburetor inlet pressure.

### Natural Gas (UL) Ultralean ( $\lambda=1.4-1.6$ )

V2-78 gas valve is used with J1-44 gas jet. The UL kit part number is CKV2-78. This gas valve starts lean of stoichiometric (approximately  $\lambda$  of 1.2) and transitions to  $\lambda$  of 1.4-1.6 (7.5 to 8.5% O<sub>2</sub>) above air flows appropriate for 80 horsepower. The power screw can adjust the A/F within this range. This valve can run richer or leaner by adjusting the power screw, but the A/F curve will be quite skewed and governor fluctuation can result. These gas valves are generally only useable with turbocharged engines, since ultralean operation on normally aspirated engines results in 1/4 to 1/3 power loss.

### Natural Gas (FR) Catalytic/Feedback/Rich ( $\lambda=0.85-0.98$ )

The FR gas valve kit part number is CKV2-88 and utilizes the V2-88 gas valve and J1-45 gas jet. This combination is designed to operate with throttling type A/F ratio controllers such as the Altronic units. These units place a control valve upstream of the carburetor in the fuel inlet. V2-88 is designed to be rich enough for proper control even under the coldest air inlet temperatures.

### Natural Gas (FB) Catalytic/Feedback/Lean ( $\lambda=1.3$ )

The FB kit part number is CKV2-89 and uses the V2-89 gas valve and J1-45 gas jet. This combination is designed to operate with enrichment type air/fuel ratio controllers. These controllers either increase gas pressure at the regulator or add fuel between the carburetor and throttle body. V2-89 can also be used with air addition lean-burn controllers such as the PSC system or for stoichiometric propane operation with the IMPCO EB converter. V2-89 should not be used in an uncontrolled application because of the potential for oil nitration at these A/F levels.

### Digester Gas (DG) 540-660 BTU/ft<sup>3</sup>, Stoichiometric ( $\lambda=1.0-1.1$ )

The DG kit part number is CKV2-79. This kit uses the V2-79 gas valve and the stainless steel J1-47 gas jet. This valve is designed for a nominal gas energy level of 600 BTU/ft<sup>3</sup> with the gas constituents primarily methane and CO<sub>2</sub>. The DG configuration requires the larger J1-48 power jet. 400VF3 carburetors with the DG prefix are already fitted with this power jet. The power screw can be set a 6 turns out for reasonable full load operation. With a higher pressure (8.0" H<sub>2</sub>O), this valve can be used with 450-480 BTU/ft<sup>3</sup> landfill gas operating at lean burn air/fuel ratios for low emissions. The higher pressure addresses the starting on a weaker gas.

### Landfill Gas (LF) 420-540 BTU/ft<sup>3</sup>, Stoichiometric ( $\lambda=1.1-1.2$ )

The LF kit (part number CKV2-80) is comprised of the V2-80 gas valve and the stainless steel J1-47 gas jet. The LF gas valve is designed for a nominal gas energy of 480 BTU/ft<sup>3</sup> with methane and CO<sub>2</sub> as the primary constituents. Like DG, LF requires the larger J1-48 power jet. 400VF3 carburetors with the LF prefix are already fitted with the J1-48 power jet. The power screw can be set at 8-9 turns out from full lean for best full load operation.

GAS VALVE	GAS JET	GAS	BTU/ft <sup>3</sup> <sup>(1)</sup>	APPLICATION
V2-77	J1-45	Natural Gas <sup>(2)</sup>	800-1000	Non-emissions, stoichiometric
V2-78	J1-44	Natural Gas		Ultralean ( $\lambda=1.4-1.6$ )
V2-79	J1-47	Digester Gas	540-660	Stoichiometric
V2-80		Landfill Gas	420-540	
V2-88	J1-46	Natural Gas	800-1000	Throttling Feedback ( $\lambda=.85-.98$ )
V2-89	J1-45	Natural Gas <sup>(2)</sup>		Enrichment Feedback ( $\lambda=1.1-1.3$ )

<sup>(1)</sup>Lower heating value.

<sup>(2)</sup>Also useable with propane via the EB converter.

## 400VF3 ORDERING INFORMATION

### 400VF3 Modular Assembly:

Except for some specific engine applications, carburetors must be ordered as sub-assembly modules and assembled by the customer/distributor. One module from each of the module groups listed below is needed to make a complete carburetor. Refer to the *Accessories & Options* for information on the Gas Valve Kits. Refer to your distributor for specific engine application carburetor availability.

#### Module Group I (Air Inlet):

AA2-70: 90°, Die cast, 4.00" hose connection  
AA2-69: In-line, Sand cast, 4.00" hose connection

#### Module Group II (400VF3 Mixer--air valve, diaphragm, spring, body, cover):

AB1-66-3X: VF3 Downdraft (w/Anti-wear bushings)  
AB1-66-3S: VF3 Sidedraft (w/Anti-wear bushings and S4-38 spring spacer)  
AB1-66-3U: VF3 Updraft (w/Anti-wear bushings and S4-39 spring spacer)

#### Module Group III (Gas Valve/Jet Kit--gas valve, jet, screw, o-ring & label):

CKV2-77: (NG) Natural gas, stoichiometric w/J1-45 (also for Propane w/EB converter)  
CKV2-78: (UL) Natural gas, ultralean ( $\lambda=1.4$  to  $1.6$ ), w/J1-44  
CKV2-79: (DG) Digester gas, (540-640 BTU/ft<sup>3</sup>), stoichiometric, w/J1-47  
CKV2-80: (LF) Landfill gas, (450-540 BTU/ft<sup>3</sup>), stoichiometric, w/J1-47  
CKV2-88: (FR) Natural gas, throttling feedback, ( $\lambda=0.85-1.05$ ), w/J1-46  
CKV2-89: (FB) Natural gas, enrichment feedback, ( $\lambda=1.2-1.4$ ), w/J1-45

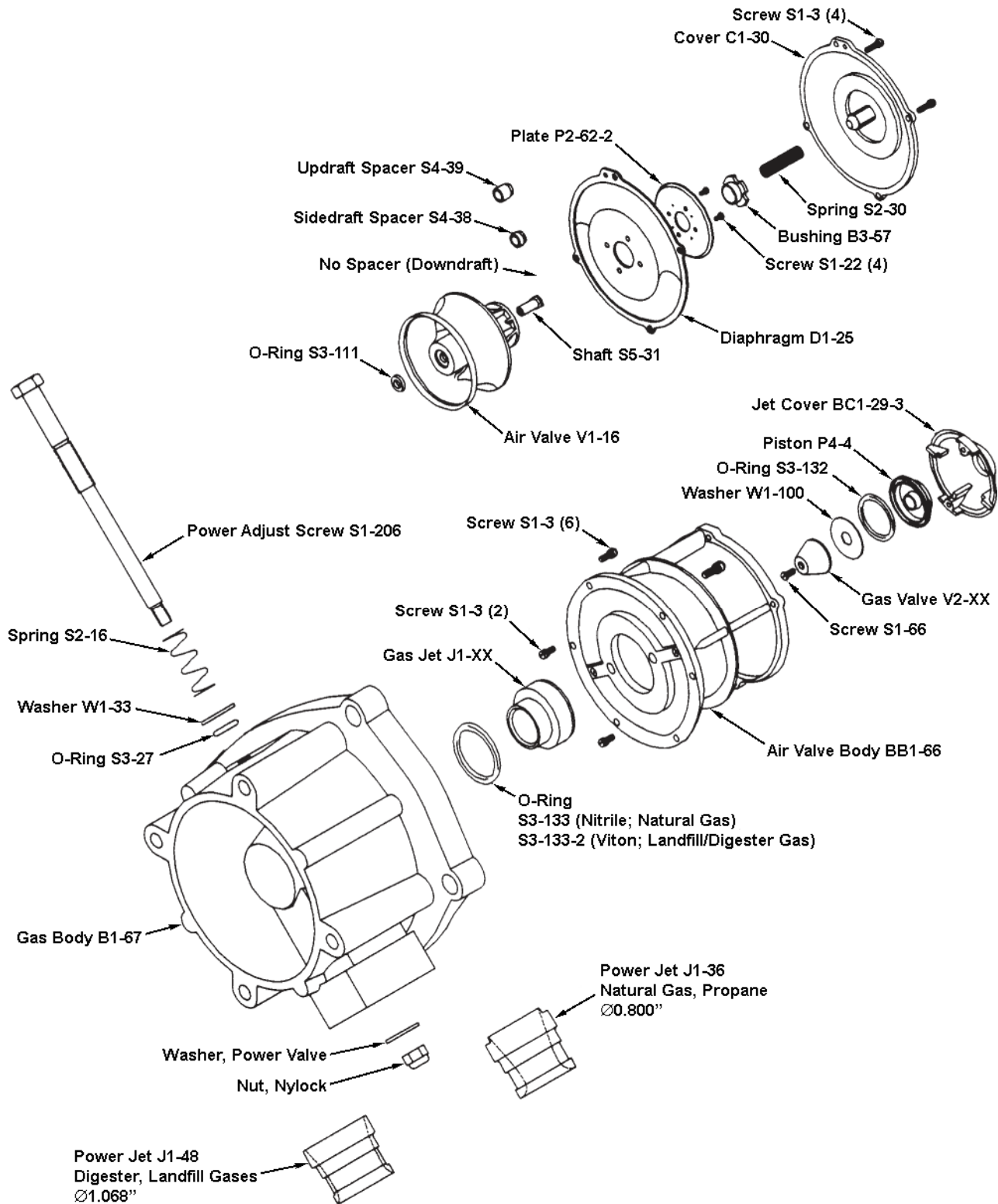
#### Module Group IV (Gas Inlet--body, power screw, jet, gaskets & bolts):

AB1-67: J1-36 Power jet, 0.800 ID (Natural gas and LPG usage)  
AB1-67-3: J1-48 Power jet, 1.080 ID (Digester and Landfill gas usage)

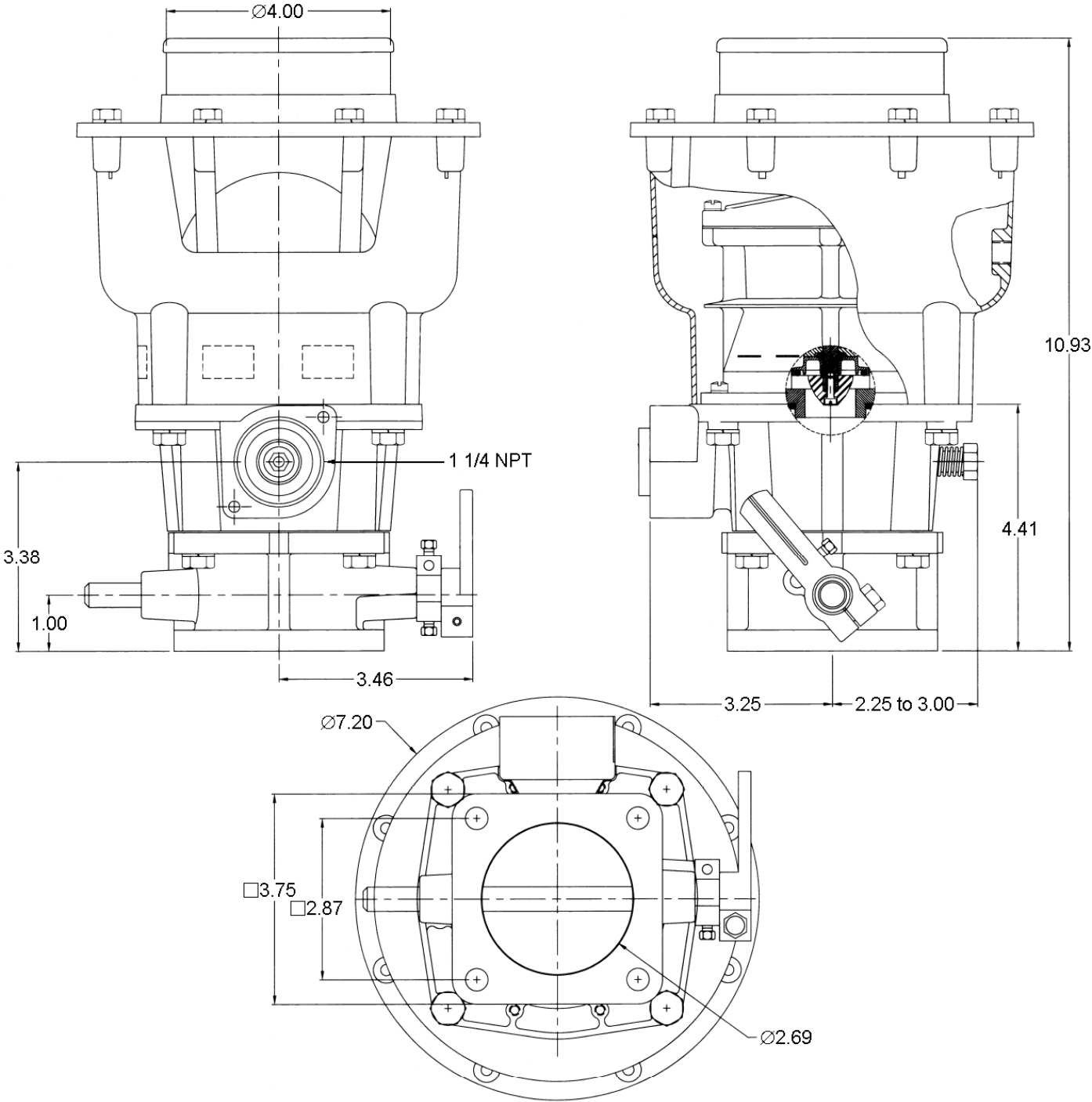
#### Module Group V (Mixture Outlet--body, fly, bearings, shaft, lever & gaskets):

AT2-7: Throttle body assembly,  $\varnothing$  2.50" bore, 2.88" bolt pattern, B3-44 bushings, 0.437" shaft  
AT2-8: Throttle body assembly,  $\varnothing$  3.00" bore, 3.25" bolt pattern, B3-44 bushings, 0.437" shaft  
AA3-128: Outlet adapter, 400VF mixer to 600VF gas body  
A3-129: Outlet adapter, 3.00" hose connection; turbo compressor inlet mounting

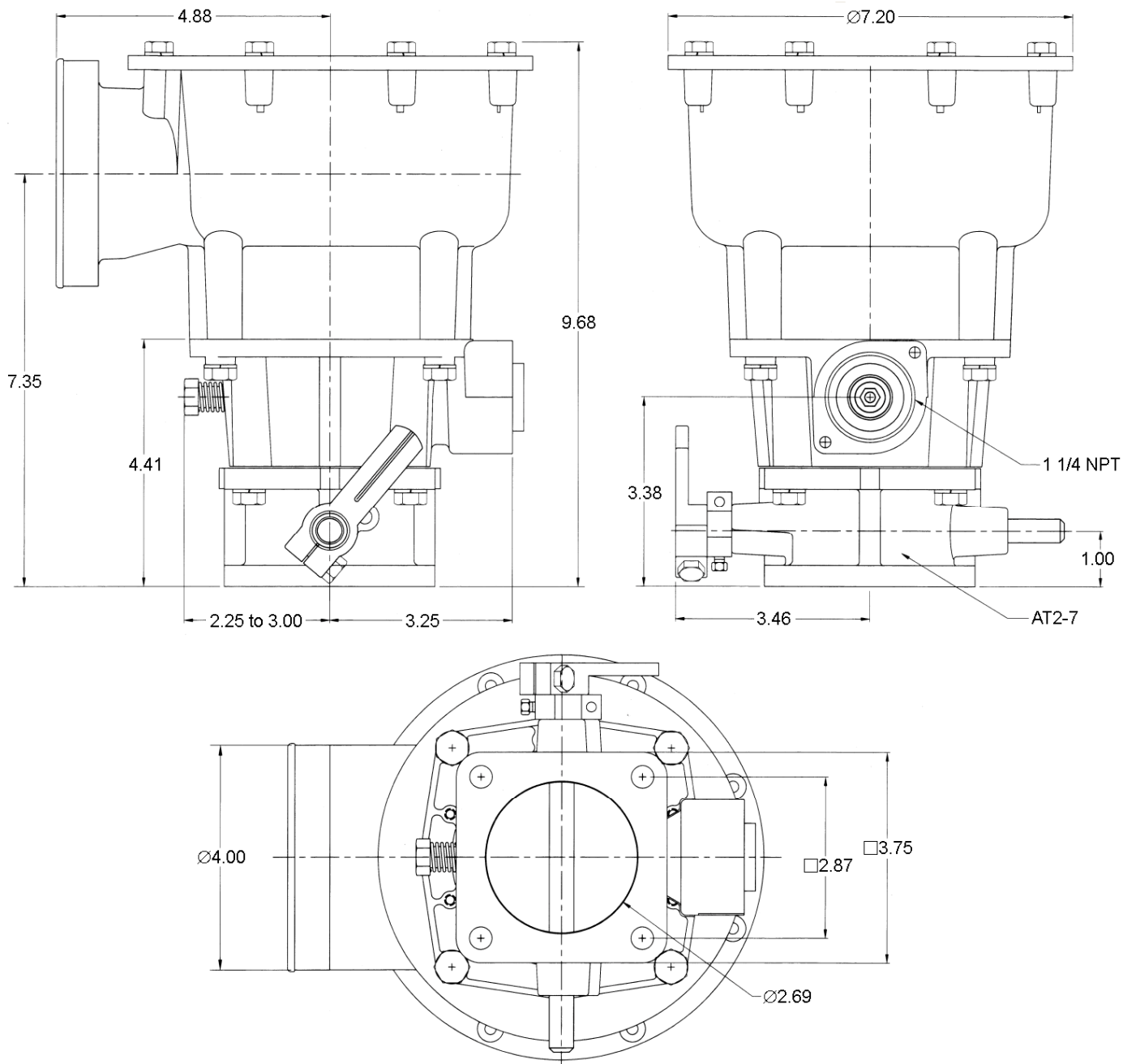
## 400VF3 Mixer Assembly (Exploded View)



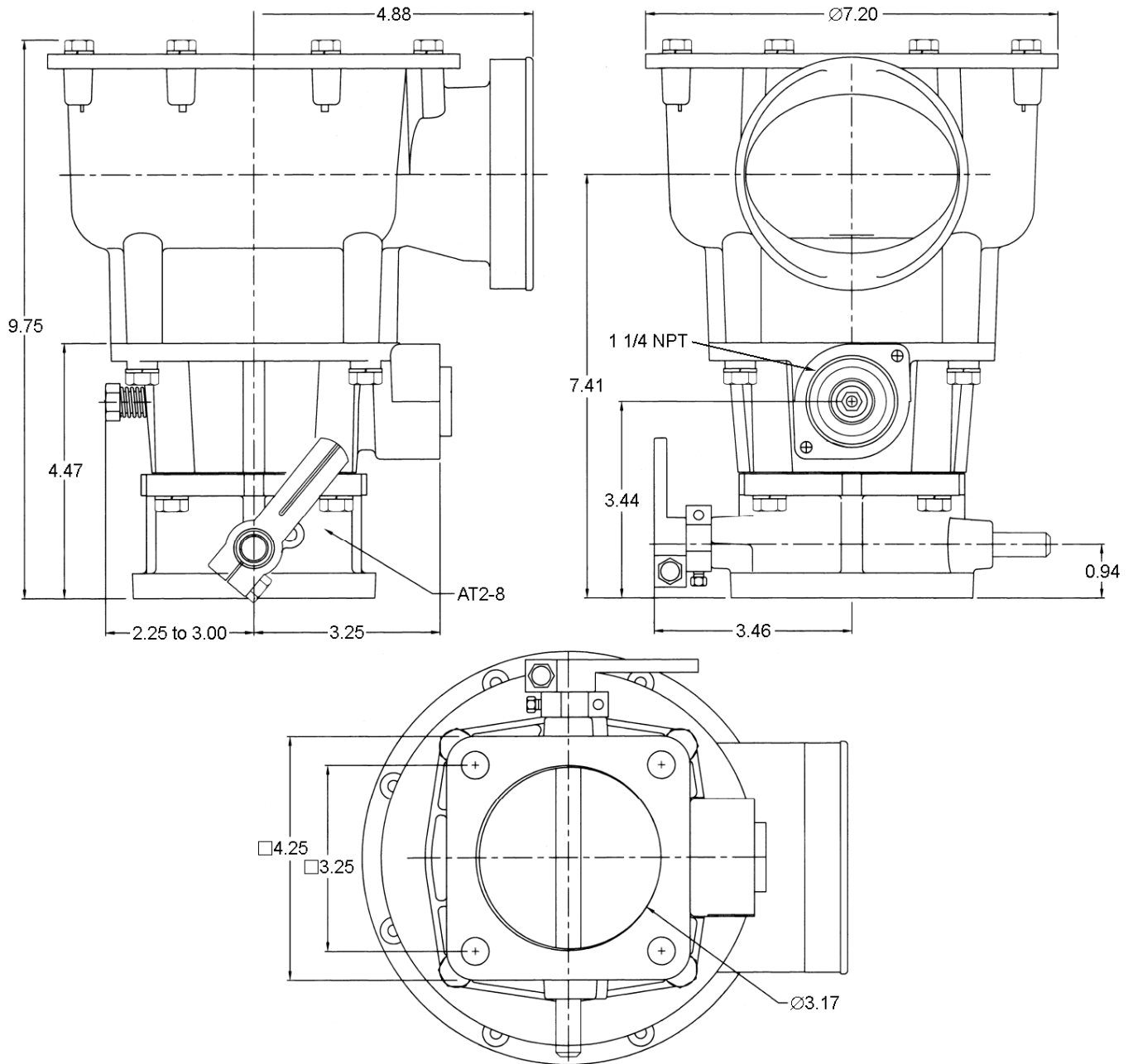
400VF3 Carburetor Dimensions (w/Straight Air Inlet/AT2-7 Outlet Module)



## 400VF3 Carburetor Dimensions (w/90° Air Inlet/AT2-7 Outlet Module)

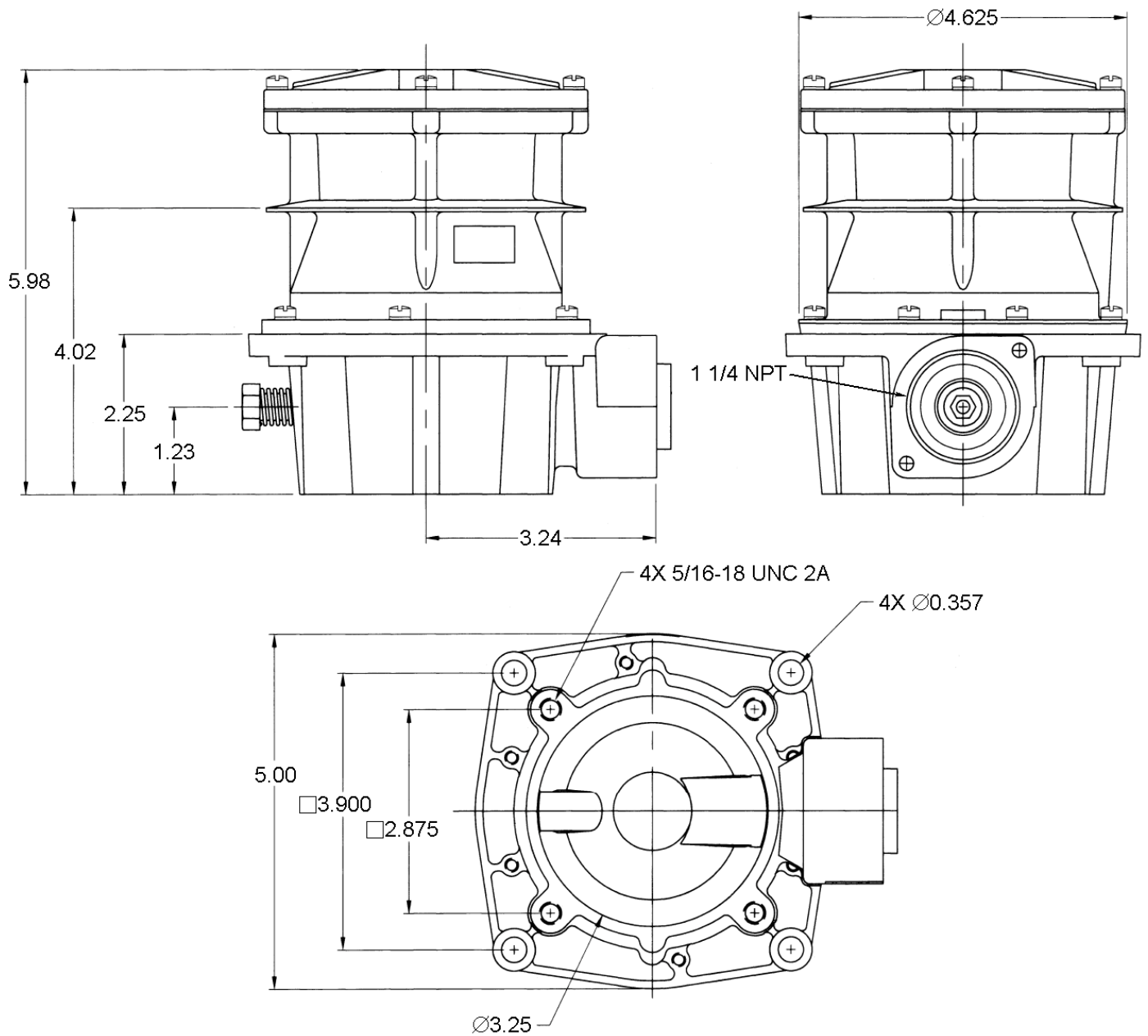


## 400VF3 Carburetor Dimensions (w/90° Air Inlet/AT2-8 Outlet Module)

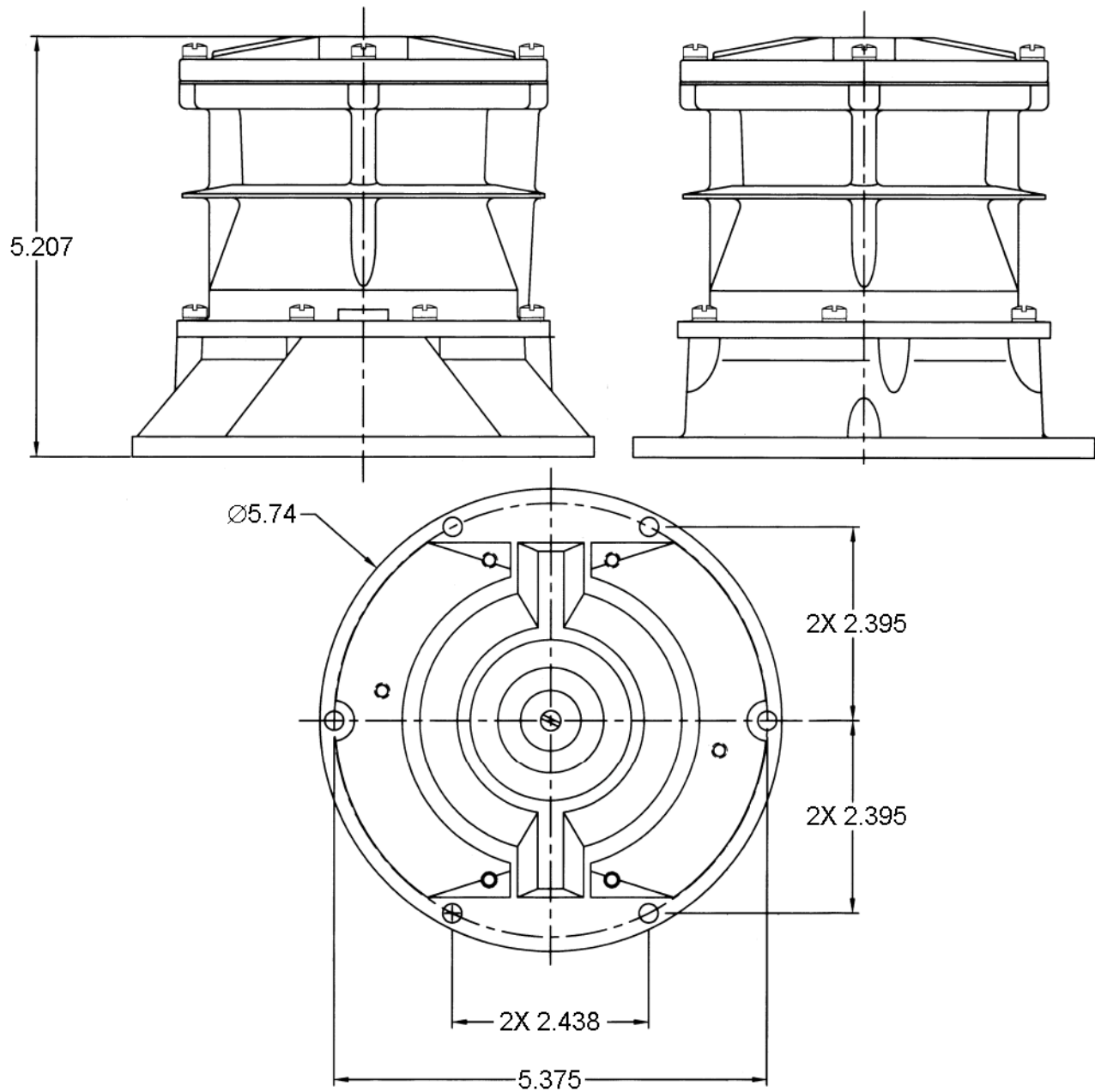




## 400VF3 Mixer Dimensions



## 400VF3 Mixer to 600VF3 Gas Body Adapter Dimensions







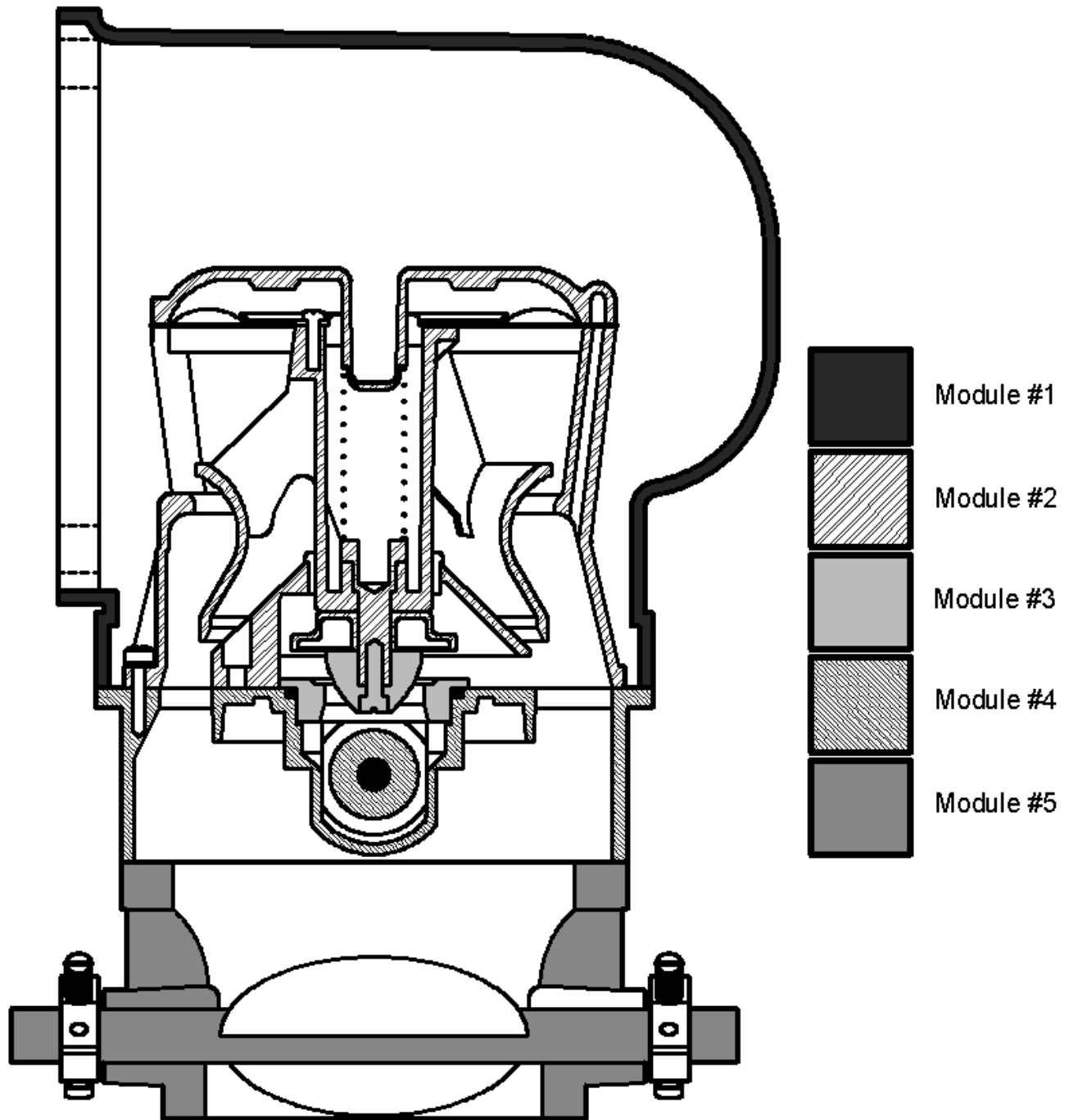
***VARIFUEL 600VF3 Carburetor***

## Model 600VF3 Specifications

Fuel Type <sup>(1)</sup> .....	Propane & LPG (50/50 Propane/Butane) Natural Gas (85%+ Methane) Digester Gas (56-72% Methane) <sup>(2)</sup> Landfill Gas (45-56% Methane) <sup>(2)</sup>
Operating Pressures:	
Gas Inlet, Normal .....	5" H <sub>2</sub> O over Air Inlet (idle setting)
Air Inlet, Maximum .....	30 PSI
Backfire, Peak .....	60 PSI
Airflow Capacity .....	960 CFM @ 2" HG Depression (T2-17 @ WOT)
Horsepower Rating .....	540 BHP (Naturally Aspirated)
Air/Fuel Ratios .....	See Gas Valve Chart on page 31
Air/Fuel Adjustments:	
Low Speed/Load .....	Regulator Pressure (External to Carburetor)
High Load .....	Power Screw (10+ Turns)
Temperature Limits:	
Max. Operating .....	250° F
Max. Soakback .....	320° F
Materials:	
Air Valve body (B1-30-6) .....	Aluminum (Hard Anodized)
Air Valve (V1-17) .....	Aluminum (Hard Anodized)
Gas Body (B1-31-2) .....	Aluminum (Hard Anodized)
Air Valve Cover (C1-32) .....	Aluminum (Hard Anodized)
Inlet Housing (A2-16 or A2-22) .....	Aluminum (Hard Anodized)
Throttle Body (T2-17, T2-67 or T2-80) .....	Aluminum (Hard Anodized)
Diaphragm (D1-20-3) .....	Fluorosilicone
Guide Bushings .....	PPS Plastic, Glass and PTFE-filled
Gas Valve .....	Aluminum (Hard Anodized)
Gas Jet .....	Aluminum (Hard Anodized); Stainless Steel (optional)
Power Valve .....	Aluminum (Hard Anodized); High Carbon Steel (Optional)
O-ring Seals .....	Buna N; Fluorocarbon optional
Fasteners & Power Screw .....	Carbon Steel, Zinc plated and baked
Springs .....	High Carbon Steel, Zinc plated and baked
Lubrication .....	None Required
Safety Certification .....	N/A (Engine User/Producer Responsibility)
Emissions Certification .....	N/A (Engine User/Producer Responsibility)

<sup>(1)</sup>Each fuel requires a unique gas valve and jet combination.

<sup>(2)</sup>Requires AB1-31-3 (J1-33 oversize power jet and W1-63 power valve).



***600VF3 Modules***

## B. Model 600VF3:

The IMPCO VARIFUEL 600VF3 is a gaseous fuel carburetor of the concentric flow air valve type. It is designed to be a direct replacement for the IMPCO 200T and IMPCO 600 carburetors. A precision gas metering valve is attached to the air valve. Both the air and gas valve motions are linear in relation to volumetric flow. The air/fuel ratio is controlled by the adjustable power valve, shape of the gas metering valve, and the pressure from the gas regulator. The gas valve and matching jet is sized for the gas to be used. Several jet sizes are available to adapt to fuels from propane to landfill gas. Gas valves are shaped to provide A/F ratio versus flow characteristics defined by the customer.

The 600VF3 is equipped with anti-wear bushings for the air valve assembly. Also, for enhanced temperature, chemical and wear resistance, the 600VF3 has a premium fluorosilicone diaphragm.

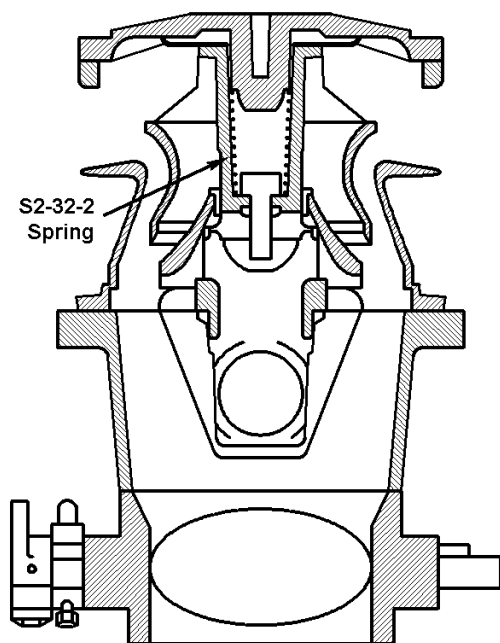
The 600VF3 is composed of five modular elements:

- 1) Air Inlet Module (Air Horn)
- 2) Mixer Module
- 3) Gas Valve/Jet Module
- 4) Gas Inlet Module
- 5) Mixture Outlet Module (Throttle Body)

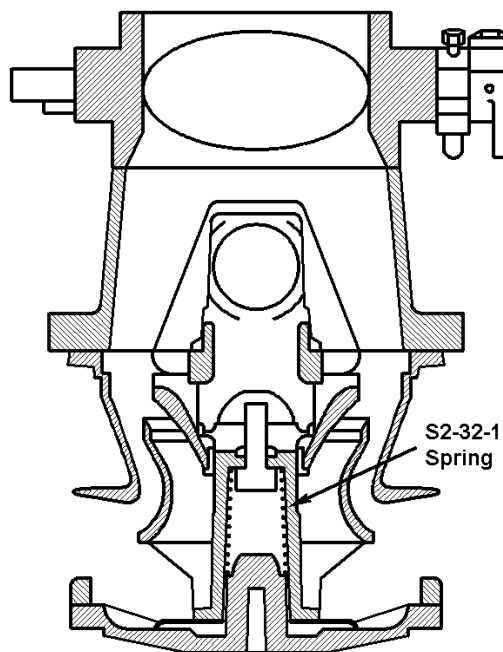
A complete carburetor consists of all five modules. Deletion of either the Air Inlet or Mixture Outlet Module yields a *mixer assembly*.

The attachment of the Air Inlet Module to the Gas Inlet Module uses a square bolt pattern, allowing four position options for the air inlet on the 90° inlet housing (A2-16). The attachment of the Gas Inlet Module to the Mixture Outlet Module uses a bi-directional bolt pattern, allowing two position options for the gas inlet piping relative to the throttle shaft and its rotation.

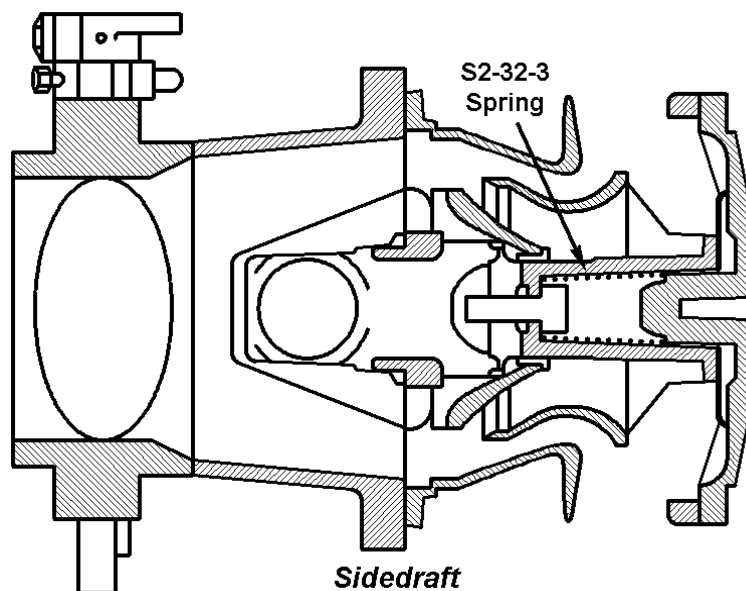
Updraft, sidedraft and downdraft versions are available for the 600VF3 Mixer Module. Starting is largely controlled by the initial motion of the air valve, which is dictated by the vacuum generated downstream of the mixer. The spring load and weight of the air valve/diaphragm assembly determine this motion. Three air valve springs are available depending on installation requirements.



***Downdraft***



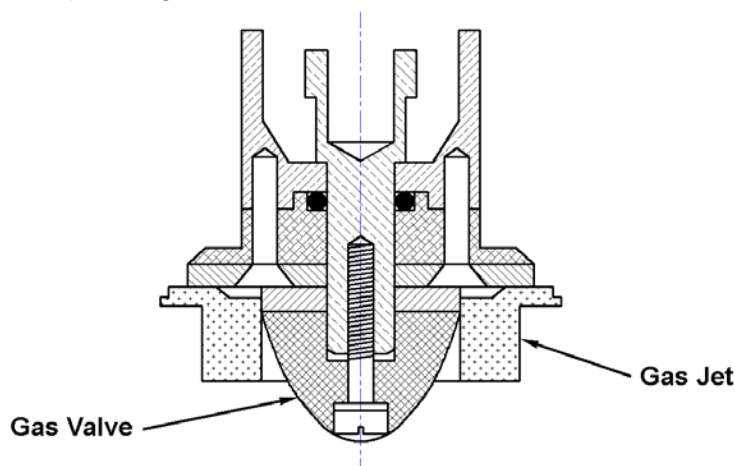
***Updraft***



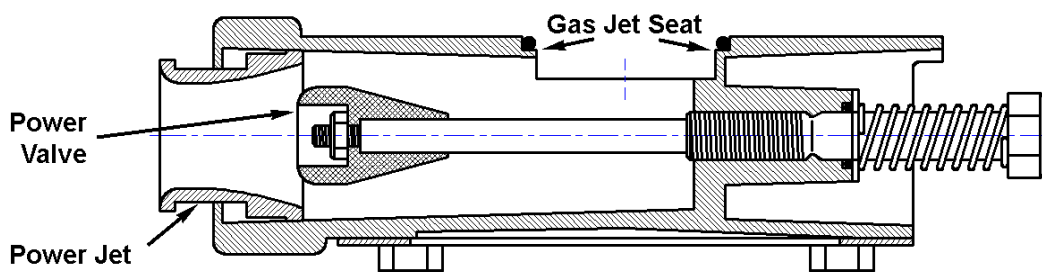
***Sidedraft***



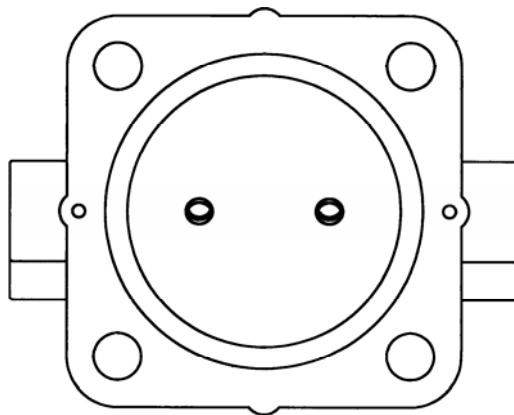
The gas valve and matching jet are sized for the gas to be used. Several jet sizes are available to adapt to fuels from propane to landfill gas. Gas valves are shaped to provide A/F versus flow characteristics defined by the customer. The gas valve shape is most crucial in the low flow (starting and light load) operating conditions.



Two versions of the Gas Inlet Module are available to address the widely varying energy densities of fuels. AB1-31-2 is used for propane, LPG and natural gas. AB1-31-3 is used for low energy density fuels such as digester, or landfill gases. A larger power jet and smaller power valve are used in the AB1-31-3 module to allow higher volumetric gas flow rates.



Two throttle bores are available:  $\varnothing 3.69"$  and  $\varnothing 4.19"$ . The smaller bore should always be the first choice. Governor stability can be a problem if too large a throttle is used. An adaptor is available to mount the 600VF3 upstream of a turbo compressor, remote from the throttle body. T2-80 has a shorter height to allow retrofitting IMPCO 200T's directly with the 600VF3 with only a gas line repositioning.



## 600VF3 ACCESSORIES & OPTIONS

### IMPCO 600VF3 VARIFUEL Gas Valve Options:

The 600VF3 VARIFUEL is designed to operate with a wide variety of fuels. From high energy propane/butane mixes to 420 BTU/ft<sup>3</sup> landfill gases, the 600VF3 can mix them in a manageable manner. To do this, five gas metering jet sizes were developed with IDs of Ø0.750", Ø1.000", Ø1.125", Ø1.250" and Ø1.400" (these jets are completely interchangeable). The two largest jets are CNC machined from stainless steel to operate in the often corrosive environments of digester and landfill gases.

Six basic gas valves are available for specific fuels and emissions control strategies. These valves are easily interchangeable with a flat blade screwdriver. For all 600VF3 gas valves, the gas inlet pressure should be set at 5-6" H<sub>2</sub>O column.

NOTE: Gas valves for specific OEM applications are available. Contact your local IMPCO distributor for more information.

### Natural Gas (NG) Non-emissions, Stoichiometric ( $\lambda=1.0$ )

V2-21-3 gas valve is used with J1-23 gas jet. The NG conversion kit can be purchased under part number CKV2-21-3. A good initial setting for the power screw is 6 turns from full lean (all the way in). The A/F can be set from lean to stoichiometric with the power screw for economic operation. Partial throttle operation on 200 to 450 HP engines will also be slightly lean.

V2-21-3 can also be used for propane operation with the IMPCO EB converter. The EB operates at - 1.5" H<sub>2</sub>O carburetor inlet pressure.

### Natural Gas (UL) Ultralean ( $\lambda=1.4-1.6$ )

V2-63 gas valve is used with J1-23 gas jet. The UL kit part number is CKV2-63. This gas valve starts lean of stoichiometric (approximately 1.2  $\lambda$ ) and transitions to  $\lambda$  of 1.4-1.6 (7.5 to 8.5% O<sub>2</sub>) above air flows appropriate for 200 horsepower. The power screw can adjust the A/F within this range. This valve can run richer or leaner by adjusting the power screw, but the A/F curve will be quite skewed and governor fluctuation can result. These gas valves are generally only useable with turbocharged engines, since ultralean operation on normally aspirated engines will result in a power loss.

### Natural Gas (FR) Catalytic/Feedback/Rich ( $\lambda=0.85-1.00$ )

The FR gas valve kit part number is CKV2-94 and utilizes the V2-94 gas valve and J1-24 gas jet. This combination is designed to operate with throttling type air/fuel ratio controllers. These units place a control valve upstream of the carburetor in the fuel inlet. V2-94 is designed to be rich enough for proper control even under the coldest air inlet temperatures. Unlike old non-VARIFUEL units, this valve should be run at lower (5.0-7.0" H<sub>2</sub>O) gas pressure or excessive richness and misfiring might occur at light loads.

### Natural Gas (FB) Catalytic/Feedback/Lean ( $\lambda=1.1-1.3$ )

The FB kit part number is CKV2-62 and uses the V2-62 gas valve and J1-22 gas jet. This combination is designed to operate with enrichment type air/fuel ratio controllers. These controllers either increase gas pressure at the regulator or add fuel between the carburetor and throttle body. V2-62 can also be used with air addition lean-burn controllers or for stoichiometric propane operation with the IMPCO EB converter. V2-62 should not be used in an uncontrolled application because of the potential for oil nitration at these A/F levels.

### Digester Gas (DG) 540-660 BTU/ft<sup>3</sup>, Stoichiometric ( $\lambda=1.0-1.1$ )

The DG kit part number is CKV2-64. This kit uses the V2-64 gas valve and the stainless steel J1-25 gas jet. This valve is designed for a nominal gas energy level of 600 BTU/ft<sup>3</sup> with the gas constituents primarily methane and CO<sub>2</sub>. The DG configuration requires the larger J1-33 power jet. 600VF3 carburetors with the DG prefix are already fitted with this power jet. The power screw can be set a 6 turns out for reasonable full load operation. With a higher pressure (8.0" H<sub>2</sub>O), this valve can be used with 450-480 BTU/ft<sup>3</sup> landfill gas operating at lean burn air/fuel ratios for low emissions. The higher pressure addresses the starting on a weaker gas.

### Landfill Gas (LF) 420-540 BTU/ft<sup>3</sup>, Stoichiometric ( $\lambda=1.1-1.2$ )

The LF kit (part number CKV2-65) is comprised of the V2-65 gas valve and the stainless steel J1-25 gas jet. The LF gas valve is designed for a nominal gas energy of 480 BTU/ft<sup>3</sup> with methane and CO<sub>2</sub> as the primary constituents. Like DG, LF requires the larger J1-33 power jet. 600VF3 carburetors with the LF prefix are already fitted with the J1-33 power jet. The power screw can be set at 8-9 turns out from full lean for best full load operation.

### Gas Valve Chart

GAS VALVE	GAS JET	GAS	BTU/ft <sup>3</sup> (1)	APPLICATION
V2-21-3	J1-23	Natural Gas <sup>(2)</sup>	800-1000	Non-emissions, stoichiometric
V2-63		Natural Gas		Ultralean ( $\lambda = 1.4-1.6$ )
V2-64	J1-25	Digester Gas	540-660	Stoichiometric
V2-65		Landfill Gas	420-540	
V2-94	J1-24	Natural Gas	800-1000	Throttling Feedback ( $\lambda = .85-.98$ )
V2-62	J1-22	Natural Gas <sup>(2)</sup>		Enrichment Feedback ( $\lambda = 1.1-1.3$ )

(1)- Lower heating value.

(2)- Also useable with propane via the EB converter.

## 600VF3 ORDERING INFORMATION

### 600VF3 Modular Assembly:

Except for some specific OEM engine applications, carburetors must be ordered as sub-assembly modules and assembled by the customer/distributor. One module from each of the module groups listed below is needed to make a complete carburetor. Refer to the *Accessories & Options* for information on the Gas Valve Kits. Refer to your distributor for specific engine application carburetor availability.

#### Module Group I (Air Inlet):

AA2-16: Ø6.00", 90°, Die cast, 5.62" bolt pattern  
AA2-22: Ø6.00", In-line, Sand cast, Ø6.00" hose connection

#### Module Group II (600VF3 Mixer--air valve, diaphragm, spring, body, cover):

AB1-30-6: Updraft, S2-32-1 spring, fluorosilicone diaphragm  
AB1-30-6H: Updraft, high flow, S2-123 spring, fluorosilicone diaphragm (Waukesha Turbo)  
AB1-30-6X: Downdraft, S2-32-2 spring, fluorosilicone diaphragm  
AB1-30-6S: Sidedraft, S2-32-3 spring, fluorosilicone diaphragm  
AB1-30-6SL: Sidedraft, short piston, S2-32-3 spring, fluorosilicone diaphragm (Turbo Draw-through usage)

#### Module Group III (Gas Valve/Jet Kit--gas valve, jet, screw, O-ring & label):

CKV2-21-3: Natural gas, stoichiometric w/J1-23 (also for Propane w/EB converter)  
CKV2-62: Natural gas, enrichment AFC for catalysts ( $\lambda=1.1-1.3$ ), w/J1-22  
CKV2-63: Natural gas, ultralean ( $\lambda=1.4$  to  $1.6$ ), w/J1-23  
CKV2-64: Digester gas, (540-640 BTU/ft<sup>3</sup>), stoichiometric, w/J1-25  
CKV2-116: Digester gas, ultralean (540-640 BTU/ft<sup>3</sup>), w/J1-24  
CKV2-65: Landfill gas, (450-540 BTU/ft<sup>3</sup>), stoichiometric, w/J1-25  
CKV2-69: Landfill gas, (450-540 BTU/ft<sup>3</sup>), w/J1-25 (10" H<sub>2</sub>O column gas pressure)  
CKV2-94: Natural gas, throttling AFC for catalysts, ( $\lambda = .85-1.05$ ), w/J1-24  
CKV2-96: LPG, stoichiometric, w/J1-22

(All gas valve kits except CKV2-69 are designed to operate w/5" H<sub>2</sub>O column gas inlet pressure.)

#### Module Group IV (Gas Inlet (body, power screw, jet, gaskets & bolts):

AB1-31-2: J1-32 power jet & V2-60 power valve (natural gas & LPG usage)  
AB1-31-3: J1-33 power jet & W1-63 power valve (digester & landfill gas usage)

## Module Group V (Mixture Outlet--body, fly, bearings, shaft, lever & gaskets):

AT2-17: Throttle body assembly, Ø4.19" bore, 4.12" bolt pattern, B3-43 bushings, Ø0.50" shaft

AT2-67: Throttle body assembly, Ø3.69" bore, 4.12" bolt pattern, B3-43 bushings, Ø0.50" shaft

AT2-80\*: Throttle body assembly, Ø3.69" bore, 3.75" bolt pattern, B3-43 bushings, Ø0.50" shaft

AA3-130: Outlet adapter, Ø3.50" O.D. hose connection (low pressure turbo mount)

\*= Used to replace 200T w/AT2-9; AT2-17-5 & AT2-67-5 are equipped with turbo seals

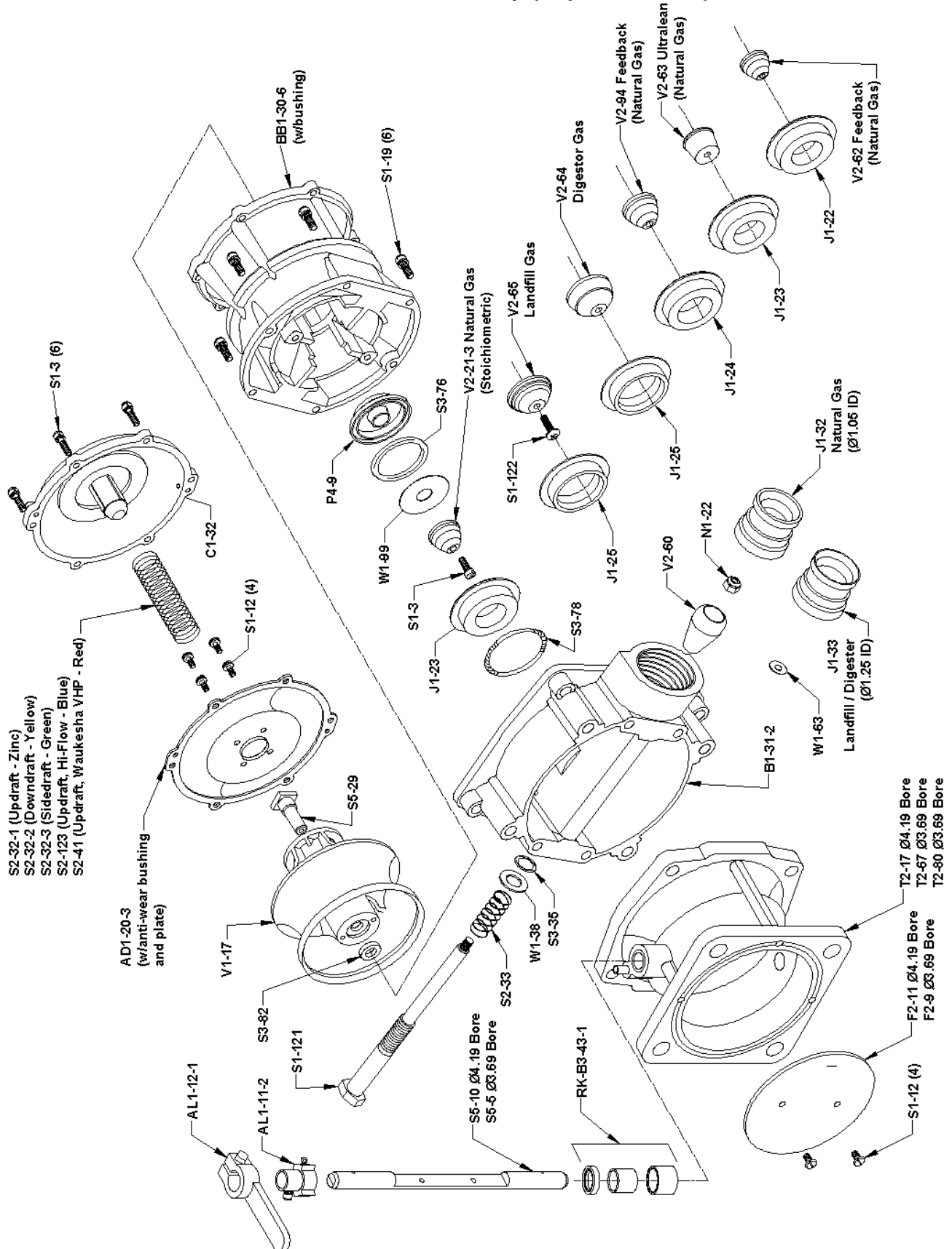
## IMPCO 600 to VARIFUEL 600VF3 Interchange

600 MODEL TO BE REPLACED	600VF3 AIR HORN MODULE	600VF3 AIR VALVE BODY ASSEMBLY	600VF3 GAS BODY ASSEMBLY	600VF3 GAS VALVE CONVERSION KIT	600VF3 THROTTLE BODY MODULE	APPLICATION	
600-1 or 600-1-2	AA2-16	AB1-30-6	AB1-31-2	CKV2-21-3 <sup>(1)</sup>	AT2-17 or AT2-67 <sup>(2)</sup>	Waukesha 3521 & 7042	
600X-1 or 600X-1-2		AB1-30-6X				CKV2-64	AT2-67
DG600X-1-2							
600X-3-2					CKV2-21-3 <sup>(1)</sup>		
600-5							
600-9							
600-77 & 600-78							
600M-2		AB1-30-6					Updraft Mixer
600XM-2		AB1-30-6X					Downdraft Mixer

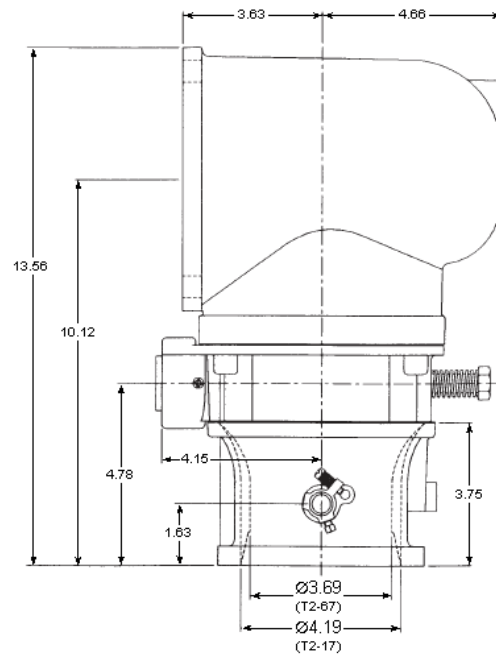
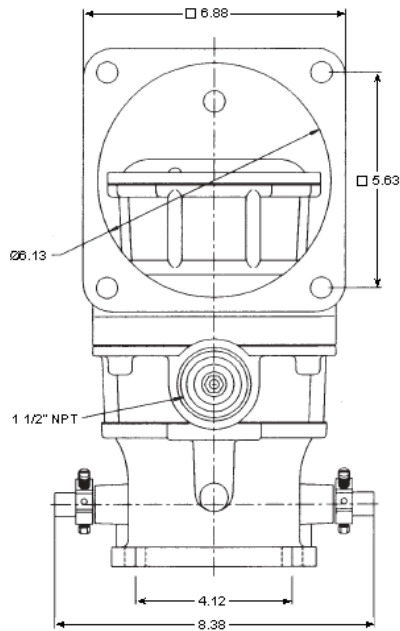
<sup>(1)</sup>Gas valve kit should be selected for the application; CKV2-21-3 will be equivalent to the old V2-21 in older 600's (see Gas Valve Chart on page 31 for gas valve options).

<sup>(2)</sup>AT2-67 is recommended for turbocharged Waukesha 3521 & 7042 engines because of improved throttle/governor control.

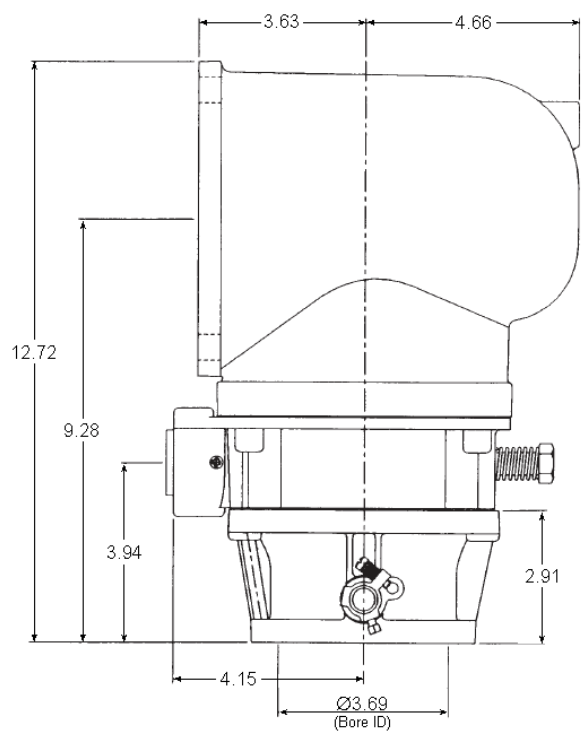
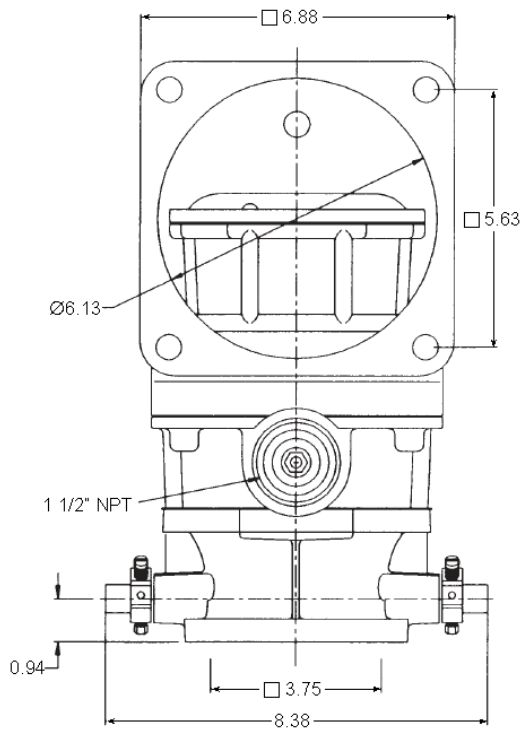
## 600VF3 Carburetor Assembly (Exploded View)



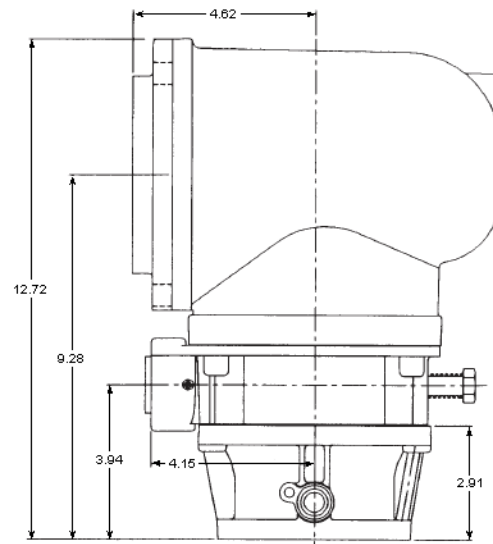
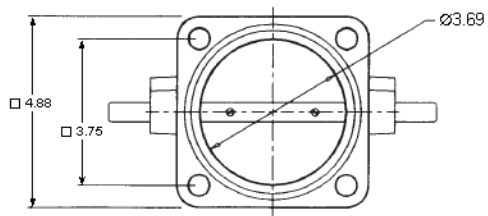
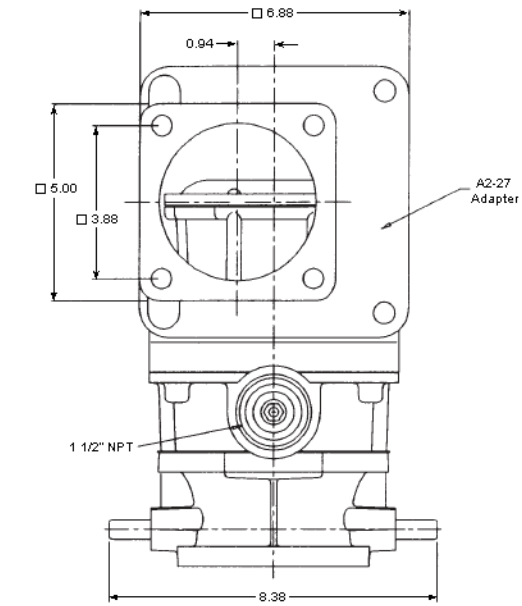
## 600VF3 Carburetor Assembly Dimensions



**Standard 600VF3 Installation Dimensions. 600 VF3 w/T2-17 Throttle Body (600-960 CFM) & 600 VF3 w/T2-67 Throttle Body (300-650 CFM).**



**600 VF3-8-2 w/T2-80 (300-650 CFM)**



**T2-80 Throttle Body**

## **600VF3 Installation Dimensions**

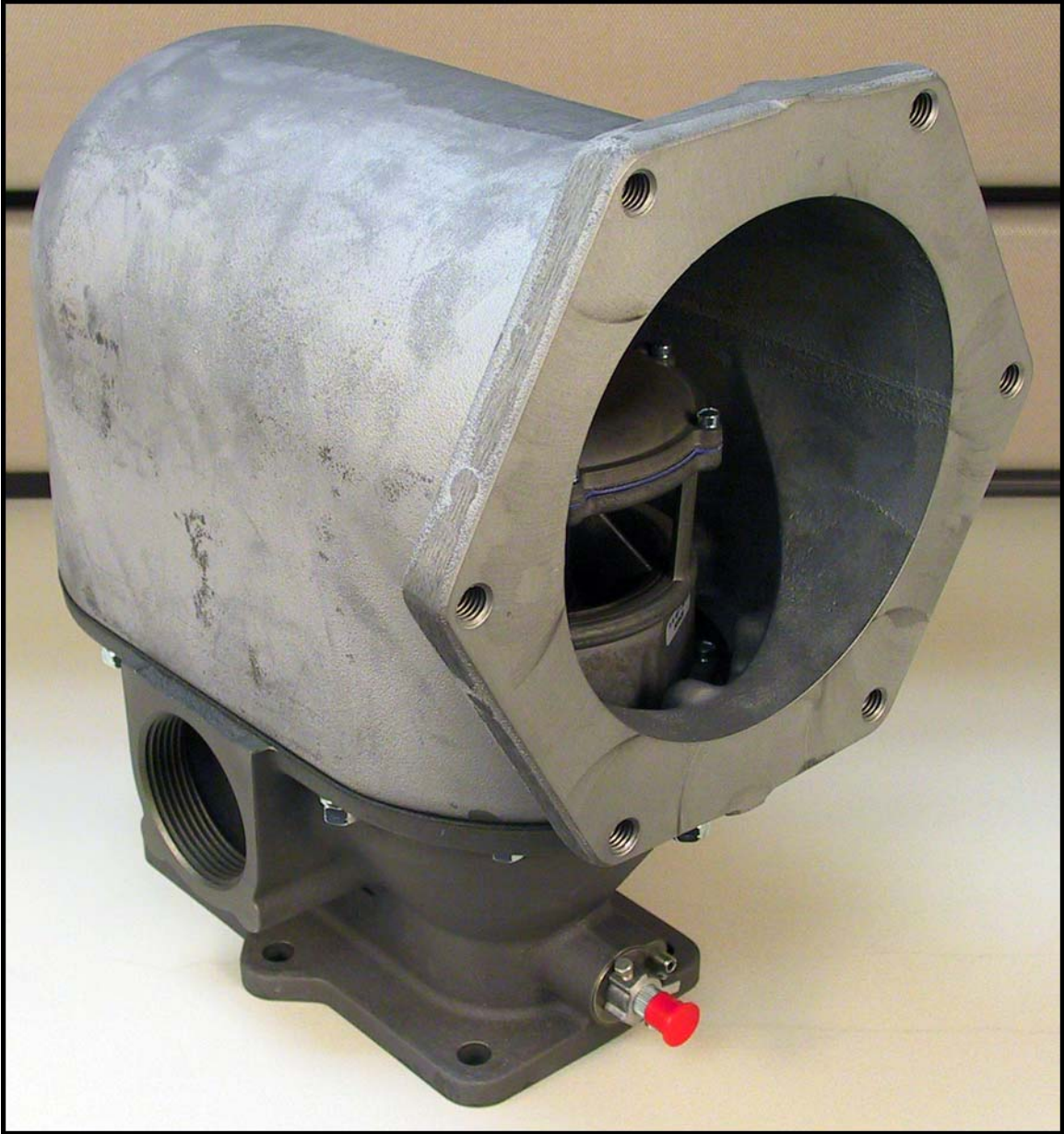
**NG600VF3X-8-2 w/ A2-27**

**Downdraft (x) with T2-80 for less than  
400 BHP per carburetor.**

**For 200T Replacement  
(Caterpillar G399TA)**





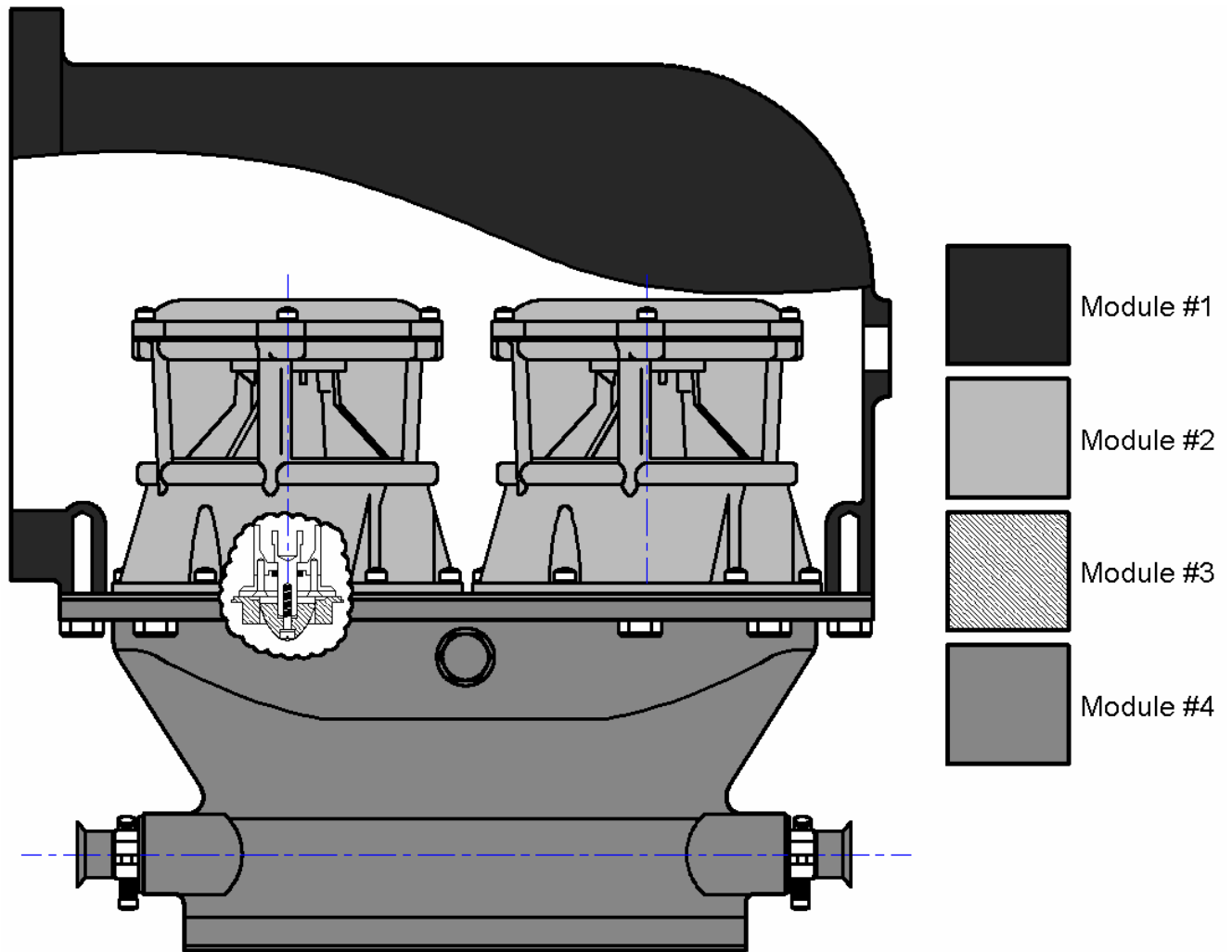


***VARIFUEL 600VF3D Duplex Carburetor***

## Model 600VF3D Specifications

Fuel Type <sup>(1)</sup> .....	Propane & LPG (50/50 Propane/Butane) Natural Gas (85%+ Methane) Digester Gas (56-72% Methane) Landfill Gas (45-56% Methane)
Operating Pressures:	
Gas Inlet, Normal .....	5" H <sub>2</sub> O over Air Inlet (idle setting)
Air Inlet, Maximum .....	30 PSI
Backfire, Peak .....	60 PSI
Airflow Capacity .....	1600 CFM @ 2" HG Depression (T2-18 @ WOT)
Horsepower Rating .....	1000 BHP (Naturally Aspirated)
Air/Fuel Ratios .....	See 600VF3 Gas Valve Chart on page 31
Air/Fuel Adjustments:	
Low Speed/Load .....	Regulator Pressure (External to Carburetor)
High Load.....	Power Screw (10+ Turns)
Temperature Limits:	
Max. Operating.....	250° F
Max. Soakback.....	320° F
Materials:	
Air Valve body (B1-30-6).....	Aluminum (Hard Anodized)
Air Valve (V1-17).....	Aluminum (Hard Anodized)
Gas Body (B1-31-2) .....	Aluminum (Hard Anodized)
Air Valve Cover (C1-32).....	Aluminum (Hard Anodized)
Inlet Housing (All).....	Aluminum (Hard Anodized)
Throttle Body (T2-18 or T2-62) .....	Aluminum (Hard Anodized)
Diaphragm (D1-20-3) .....	Fluorosilicone
Guide Bushings.....	PPS Plastic, Glass and PTFE-filled
Gas Valve.....	Aluminum (Hard Anodized)
Gas Jet.....	Aluminum (Hard Anodized); Stainless Steel (optional)
O-ring Seals .....	Buna N; Fluorocarbon optional
Fasteners & Power Screw.....	Carbon Steel, Zinc plated and baked
Springs .....	High Carbon Steel, Zinc plated and baked
Lubrication .....	None Required
Safety Certification.....	N/A (Engine User/Producer Responsibility)
Emissions Certification .....	N/A (Engine User/Producer Responsibility)

<sup>(1)</sup>Each fuel requires a unique gas valve and jet combination. Refer to 600VF3 section for availabilities.



**600VF3D Module**

### C. Model 600VF3D:

The IMPCO VARIFUEL 600VF3 Duplex carburetor is comprised of two VARIFUEL 600VF3 mixers mounted to a common Throttle/Gas Inlet Body. The 600VF3D can accommodate up to 1000 horsepower engines with CFM requirements of up to 1600 CFM and a range of fuels from 400 BTU/ft<sup>3</sup> Biogas, to 2500 BTU/ft<sup>3</sup> LPG. The 600VF3D carburetor is designed to be a direct replacement for the IMPCO 600D carburetor.

The VARIFUEL 600VF3D is slightly different from the 400VF3 and 600VF3 in that a carburetor is made up from four modules instead of five. The four modules consist of:

- 1) Air Inlet Module (Air Horn)
- 2) Mixer Modules (600VF3- 2X)
- 3) Gas Valve/Jet Module
- 4) Mixture Outlet (Throttle Body) Module (combination Gas Inlet/Mixture Outlet Module)

The VARIFUEL 600VF3D is available as a carburetor assembly comprised of all four modules, or available without the Air Inlet Module.

Since the VARIFUEL 600VF3D carburetor utilizes two VARIFUEL 600VF3 Mixer Modules, it can be mounted in updraft, downdraft or sidedraft configurations. Also, many different gas valves and gas jets are available to address fuel types and BTU/ft<sup>3</sup> content. Please refer to the 600VF3 section for descriptions and part numbers.

There are two Throttle Body Modules available for the 600VF3D depending on engine rated BHP.

They are:

- BT2-62-2 for 400 BHP to 799 BHP engines
- BT2-18-3 for 800 BHP to 1000 BHP engines

The throttle bodies also house the 2" NPT gas inlet. High load adjustments are made by first adjusting the fuel pressure and, then fine tuning with the spring-loaded power mixture screw (riveted to the Power Valve). Unlike the 400VF3 and the 600VF3, no additional Power Valve/Jet kit is required for different fuel applications.

NOTE: Gas valves for specific OEM applications are available. Contact your local IMPCO distributor for more information.

## 600VF3D Ordering Information

### 600VF3D Modular Assembly:

Except for some specific engine applications, carburetors must be ordered as sub-assembly modules and assembled by the customer/distributor. One module from each of the module groups listed below is needed to make a complete carburetor. Refer to the *Accessories & Options* in the 600VF3 section for information on the Gas Valve Kits. Refer to your distributor for specific OEM carburetor availability.

#### Module Group I (Air Inlet):

- AA2-17: Air Horn, Ingersoll-Rand 8SVG
- AA2-18: Air Horn, 8" diameter, 90° (side)
- AA2-23: Air Horn, Ingersoll-Rand 10SVG, 12SVG
- AA2-62: Air Horn, 8" diameter, 90° (end)
- AA2-38: Adapter Assembly, Ingersoll-Rand 8SVG
- AA2-44: Adapter Assembly, Ingersoll-Rand 10SVG, 12SVG

#### Module Group II (600VF3 Mixer--air valve, diaphragm, spring, body, cover):

- AB1-30-6: Updraft, S2-32-1 spring, fluorosilicone diaphragm
- AB1-30-6H: Updraft, high flow, S2-123 spring, fluorosilicone diaphragm (Waukesha Turbo)
- AB1-30-6X: Downdraft, S2-32-2 spring, fluorosilicone diaphragm
- AB1-30-6S: Sidedraft, S2-32-3 spring, fluorosilicone diaphragm
- AB1-30-6SL: Sidedraft, short piston, S2-32-3 spring, fluorosilicone diaphragm (Turbo Draw-through usage)

#### Module Group III (Gas Valve/Jet Kit--gas valve, jet, screw, O-ring & label):

- CKV2-21-3: Natural gas, stoichiometric w/J1-23 (also for Propane w/EB converter)
  - CKV2-62: Natural gas, enrichment AFC for catalysts ( $\lambda=1.1-1.3$ ), w/J1-22
  - CKV2-63: Natural gas, ultralean ( $\lambda=1.4$  to  $1.6$ ), w/J1-23
  - CKV2-64: Digester gas, (540-640 BTU/ft<sup>3</sup>), stoichiometric, w/J1-25
  - CKV2-116: Digester gas, ultralean (540-640 BTU/ft<sup>3</sup>), w/J1-24
  - CKV2-65: Landfill gas, (450-540 BTU/ft<sup>3</sup>), stoichiometric, w/J1-25
  - CKV2-69: Landfill gas, (450-540 BTU/ft<sup>3</sup>), w/J1-25 (10" H<sub>2</sub>O column gas pressure)
  - CKV2-94: Natural gas, throttling AFC for catalysts, ( $\lambda=.85-1.05$ ), w/J1-24
  - CKV2-96: LPG, stoichiometric, w/J1-22
- (NOTE: All gas valve kits except CKV2-69 are designed to operate w/5" H<sub>2</sub>O column gas inlet pressure.)

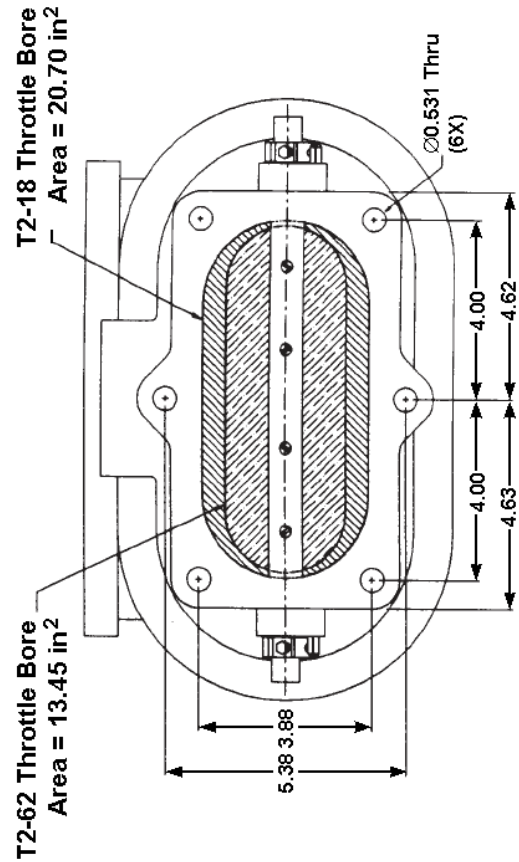
**Module Group IV (Mixture Outlet--body, power screw/power valve, fly, bearings, shaft, lever & gaskets):**

- AT2-18: Throttle body assembly, 2070 in<sup>2</sup> area throttle bore, B3-42 permaglide bearings, Ø0.75" shaft (stepped to Ø0.75" at bearings)
- AT2-62: Throttle body assembly, 13.45 in<sup>2</sup> area throttle bore, B3-42 permaglide bearings, Ø0.75" shaft (stepped to Ø0.50" at bearings)

**IMPCO 600D to VARIFUEL 600VF3D Interchange**

600D MODEL TO BE REPLACED	600D AIR HORN MODULE	600VF3 AIR VALVE BODY ASSEMBLY	BASE ADAPTER	600VF3 GAS VALVE CONVERSION KIT	600D THROTTLE BODY MODULE	APPLICATION
600D-1 or 600D-1-2	AA2-18-2	AB1-30-6	AA3-38	(2X) CKV2- 21-3 <sup>(1)</sup>	AT2-18-3	Waukesha 3521
600DX-1 or 600DX-1-2		AB1-30-6X			AT2-18-573	Superior 8G-825
600DX-3-2	AA2-17	AB1-30-6X + P2-59	AA3-44	CKV2-94	AT2-62-2	Ingersoll-Rand SVG 8 or 10
600DX-2-2	AA2-23	(2X) AB1- 30-6X		(2X) CKV2-94		Ingersoll-Rand KVG 10 or 12

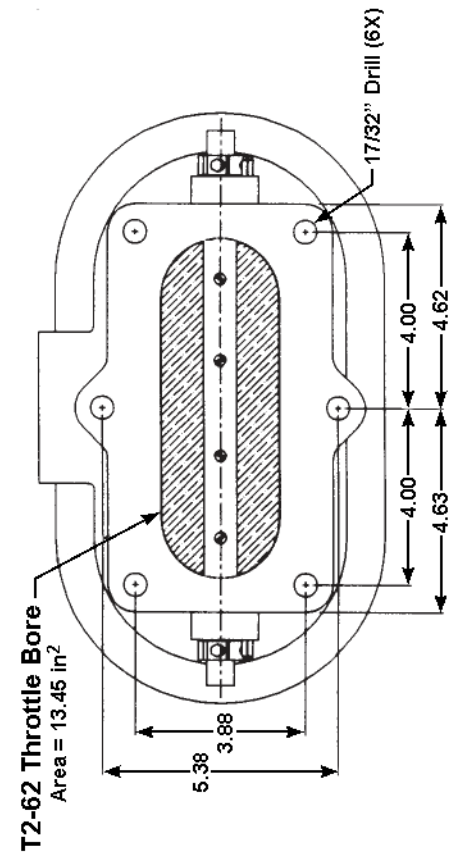
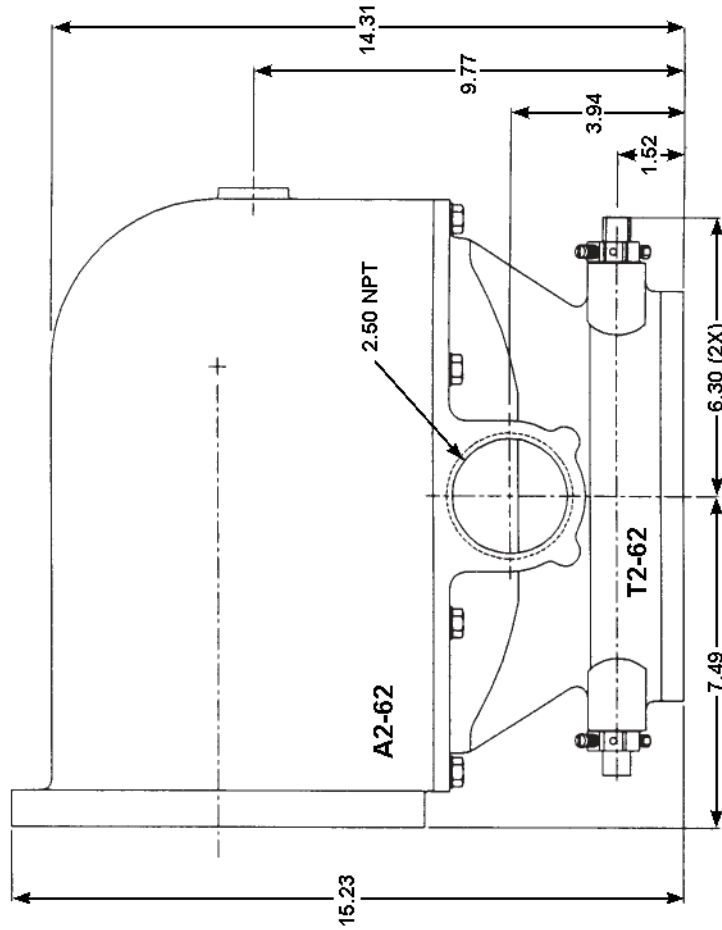
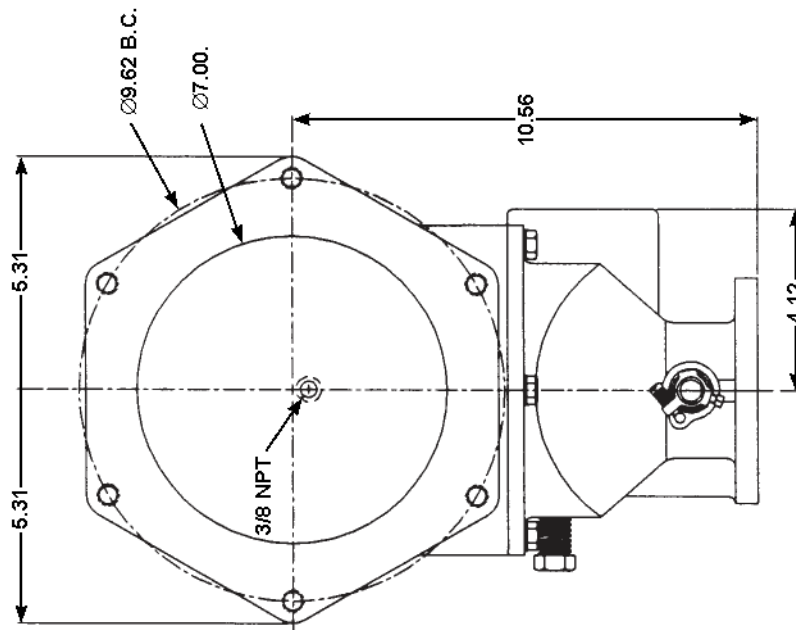
<sup>(1)</sup>Gas valve kit should be selected for the application; CKV2-21-3 will be equivalent to the V2-21 in older 600's. See chart in *600VF3 Accessories and Options* section for gas valve options.



**with T2-18 Throttle / Gas Body**  
For greater than 800 BHP per Carburetor

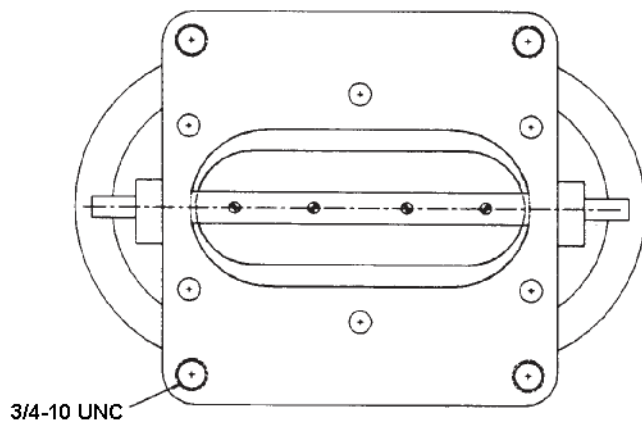
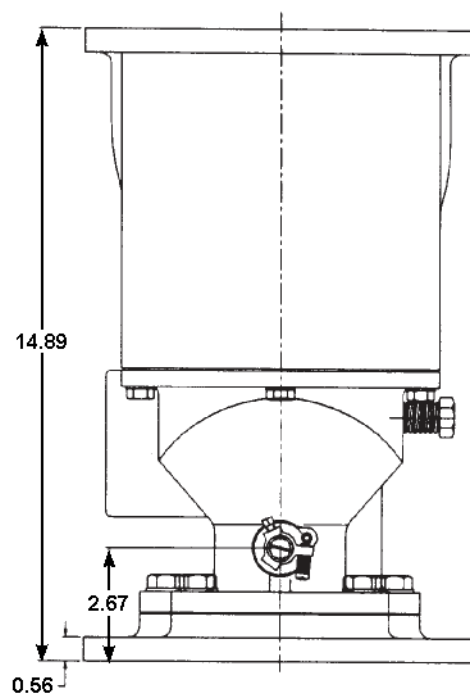
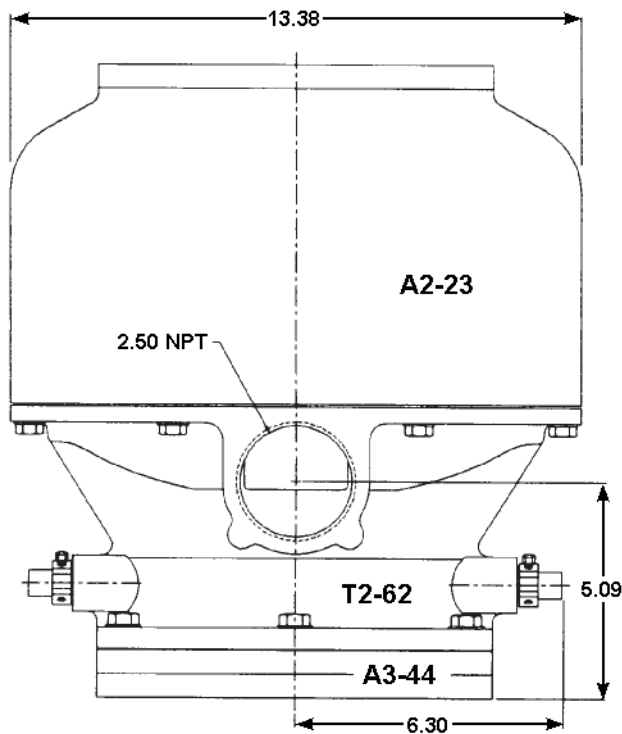
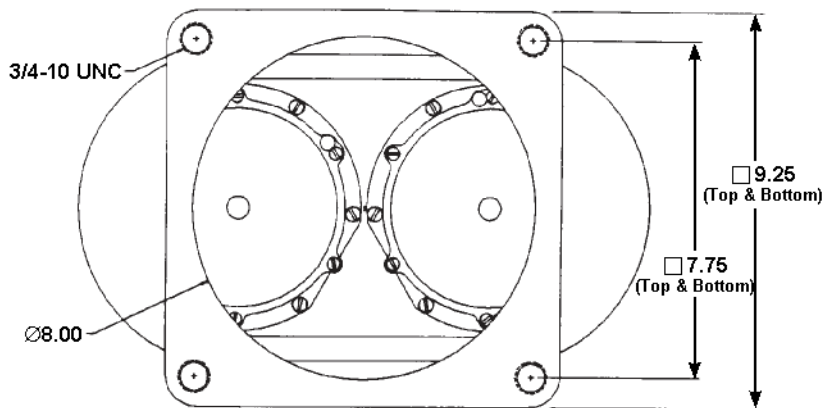
**with T2-62 Throttle / Gas Body**  
For greater than 400 BHP, but less than 800 BHP per Carburetor





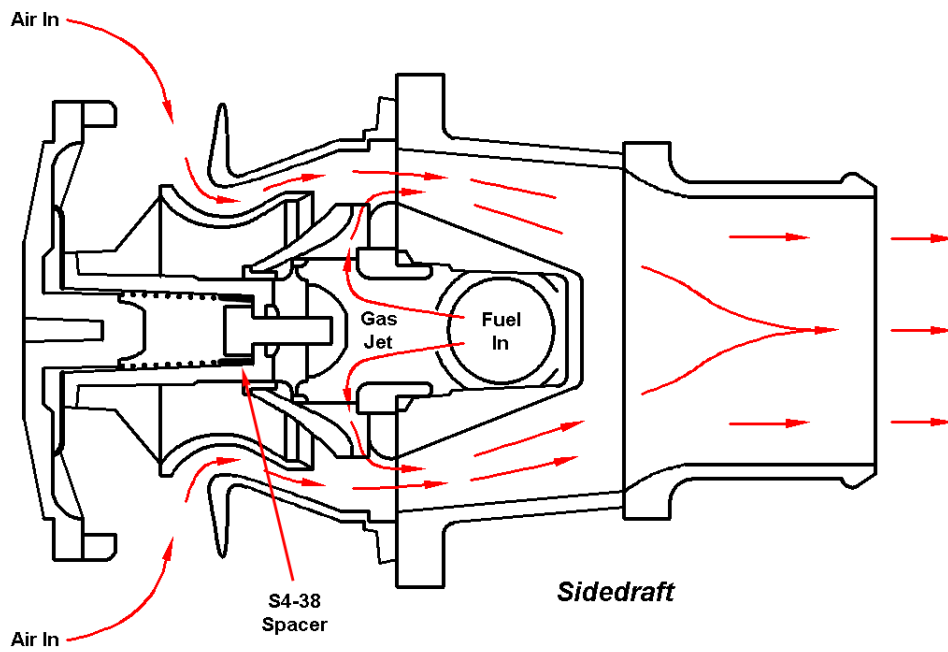
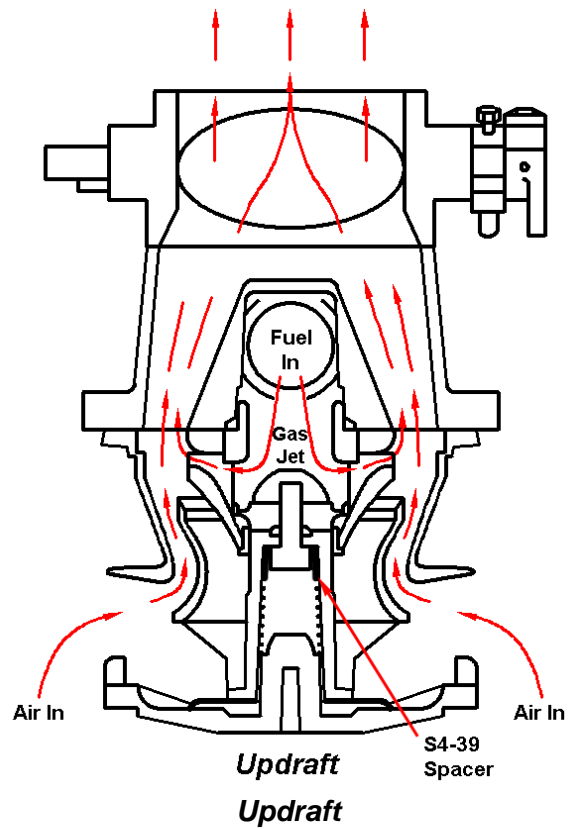
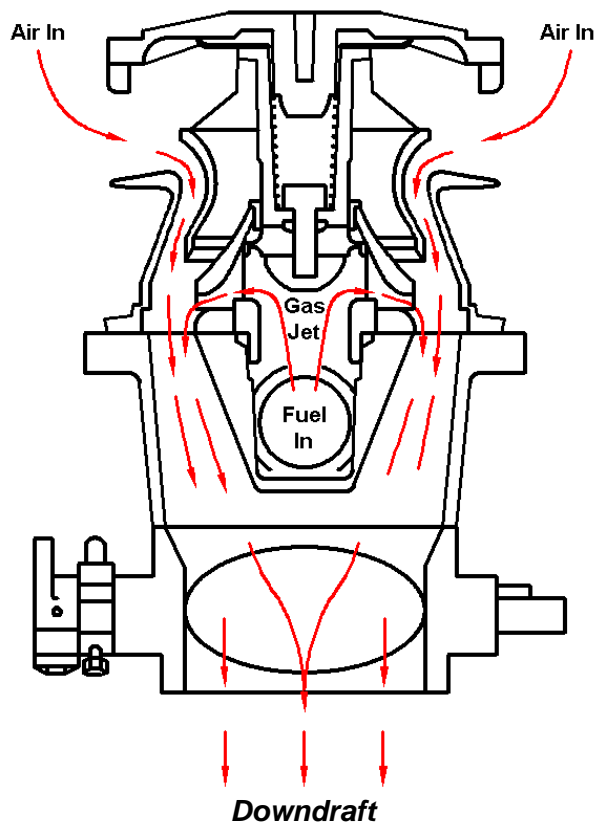
**600VF3D VARIFUEL**  
**Double Mixer Carburetor**  
 with: T2-62 Throttle / Gas Body  
 A2-62 Intake Module  
 For greater than 400 BHP, but less than  
 800 BHP per Carburetor





**600VF3D VARIFUEL**  
**Double Mixer Carburetor**  
 (For Ingersoll-Rand KVG 10's & 12's)  
 with: T2-62 Throttle / Gas Body  
 A3-44 Manifold Adapter  
 A2-23 Intake Module

For greater than 400 BHP, but less than  
 800 BHP per Carburetor



**400VF3 Installation Orientations**

# IMPCO VARIFUEL Carburetor Installation

## A. 400VF3 Carburetor

### Introduction:

The VARIFUEL 400VF3 was designed to be a bolt-on replacement for the IMPCO 200D. However, the 400VF3 (as with all VARIFUEL carburetors) allows you to change its internal gas valves and jets to accommodate different fuel types and air/fuel ratios. Also, you can fine tune the air/fuel ratio by adjusting the fuel pressure and power-adjust screw. Figure #1 is the 200D and figure #2 is the 400VF3. Notice that the fuel inlet on the 400VF3 is in a different position than the 200D. This illustration of the 400VF3 shows the fuel inlet on the right side (just below the air horn intake). However, the fuel inlet (part of the Gas Inlet Module) can be rotated to four different positions in relation to the air horn and throttle body.



**Figure #1**



**Figure #2**

### Mounting Options:

The VARIFUEL 400VF3 carburetor can be mounted in a downdraft, updraft or sidedraft configuration. Referring to the illustrations on the facing page, the updraft installation has the throttle body on top and the downdraft has the throttle body on the bottom. Note the part number for the air valve spring spacer on the updraft and sidedraft illustrations. The downdraft installation does not require a spacer. If the installation orientation needs to be changed, then the proper spacer will have to be installed (or removed). The illustration of the sidedraft installation shows the 400VF3 with the optional turbo compressor mounting adaptor (A3-129).

Additionally, the different modules can be installed at 90° increments to one another. Starting with the throttle body, it can be rotated in 90° increments to the intake manifold

giving you four different positions in which to line-up the throttle arm to the governor. Also, the gas inlet can be rotated in 90° increments to the throttle body with a resultant four different positions. Finally, the 90° air horn (AA2-70) can be rotated in 90° increments, or can be replaced with the straight in-line air horn (AA2-69). This allows for five different orientations for installation to the intake hose.

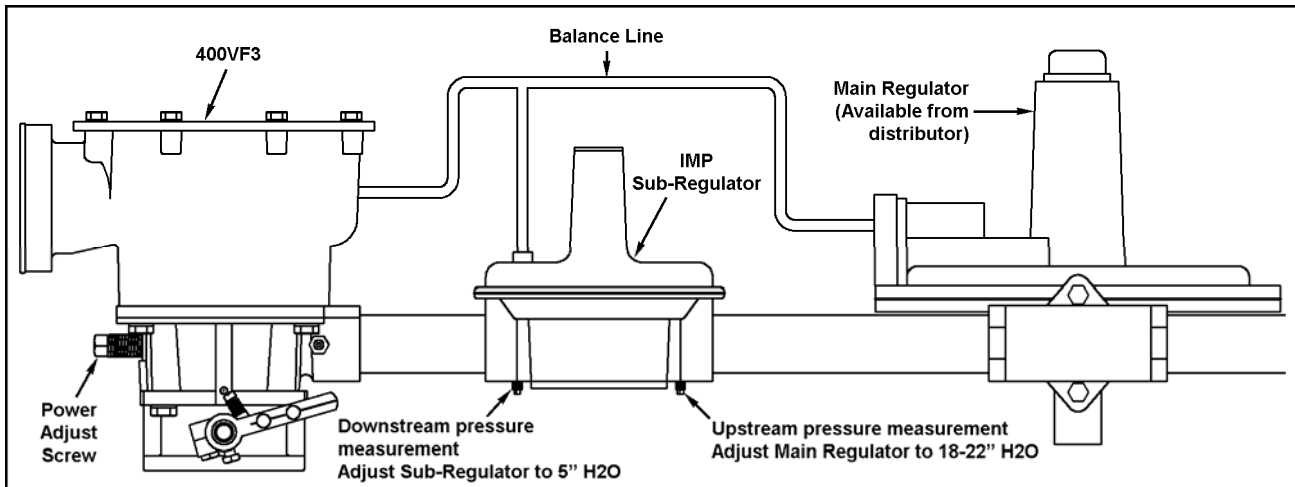
The following installation instructions are tailored to the standard downdraft installation. In this installation, the throttle body is on the bottom and the air horn is on top. If your installation is going to position the carburetor in an updraft or sidedraft position, reverse the references for the updraft installation, or change to left and right for the sidedraft installation (as warranted).

### **Installing the 400VF3 Carburetor:**

If the carburetor was not assembled by your distributor (or the module orientations need to be changed), then decide how each module will orient themselves to one another. Trial fit the modules in place on the intake manifold. Mark their orientations to each other with a felt marker across the mating surfaces. It is not necessary to remove the Mixer Module from the Gas Inlet Module. Also, it is not advisable to assemble the carburetor on the engine. Start by assembling the carburetor in the following sequence:

- 1) First, install the Gas Inlet Module to the Mixture Outlet Module (throttle body) with the orientation markings lined up. Place a new gasket (G1-25) on top of the Mixture Outlet Module and install the Gas Inlet Module with four 5/16"-18 x 7/8" hex bolts. DO NOT use any sealant on the gasket. Tighten the bolts evenly in a cross pattern to 10 in-lb, then finish torquing to 11-14 ft-lbs in the same cross pattern.
- 2) You will now be installing the carburetor (minus Air Inlet Module) onto the intake manifold. Place a new gasket (G1-27 for naturally aspirated engines, G1-27-2 for turbocharged engines) in place on the clean intake manifold. DO NOT use any gasket sealant as some fuels can break down different sealant compounds. As long as all mounting surfaces are clean and flat, there should be no problems with gaskets sealing properly. Place the carburetor over the gasket and install it using four 5/16" bolts. Tighten the bolts evenly in a cross pattern to 10 in-lb, then finish torquing to 11-14 ft-lbs in the same cross pattern.
- 3) Next, install the Air Inlet Module. Lightly lubricate the o-ring (S3-138) with clean engine oil. Install the o-ring around the base of the mixer by stretching it slightly. Again, DO NOT use any sealant. Position the Air Inlet Module (in the correct orientation) and slide it down against the o-ring. Install the four 5/6"-18 hex bolts. Tighten the bolts evenly in a cross pattern to 10 in-lb, then finish torquing to 11-14 ft-lbs in the same cross pattern.

## Installing the Fuel System:

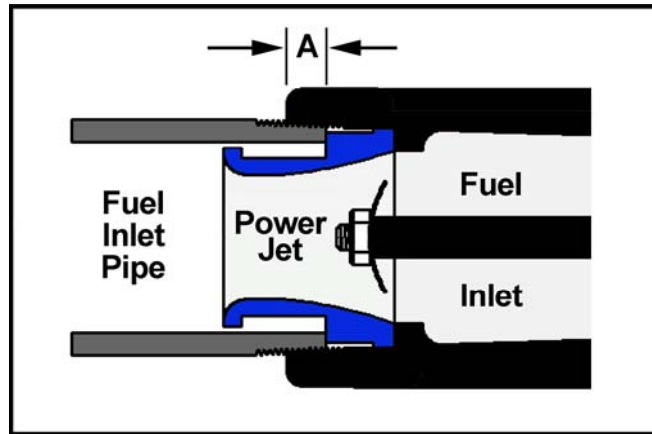


**Figure #3**

The gas valves in the 400VF3 are designed for a nominal fuel inlet pressure of 5" H<sub>2</sub>O (measured with engine running at fast idle). For this reason, the fuel pressure regulator should be located close to the sub-regulator, with as few elbows as possible to keep fuel flow restriction at a minimum (45° elbows are preferred over 90° elbows). The correct installation requires a regulator and sub-regulator (see figure #3). In this case, the main regulator produces around 20" H<sub>2</sub>O fuel pressure, and the sub-regulator (located within two feet of the carburetor) delivers 5" H<sub>2</sub>O fuel pressure to the carburetor. For more information on installing regulators and sub-regulators, refer to *Installing Regulators and Sub-Regulators* in the *Pressure Regulators* section.

Follow these directions for the fuel system connections:

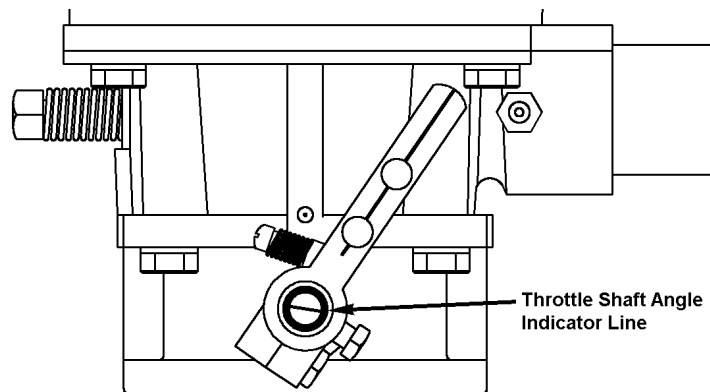
- 4) Connect the fuel line to the carburetor. If you are replacing an IMPCO 200D, then you may need to reroute the fuel pipes and regulator as the 400VF3 has a different fuel inlet location than the 200D. Use 1 ¼" NPT pipe (refer to your local code for correct type). Note that the pipe threads into the Gas Inlet Module body and fits around the aluminum power jet in the fuel inlet. Also, the pipe compresses against the flange on the power jet locking it into the gas inlet (see figure #4). Before installing the pipe, (using a pocket ruler) measure the distance from the outside face of the fuel inlet to the flange face of the power jet (measurement "A" on figure #4). Mark the fuel pipe the same distance from the end with a felt pen. The pipe should be tightened securely. However, if the torque required to tighten the pipe suddenly increases sharply, the end of the pipe has probably seated against the jet boss and should not be tightened any further. DO NOT over-torque or under-torque the pipe. If it will not reach the mark without over torquing, then remove the pipe and cut a few more threads with the appropriate NPT die. If it bottoms out without adequate torque to seal the threads, try another section of pipe or cut 1/8"- 3/16" from the end of the pipe. DO NOT use Teflon™ tape on pipe threads. Use a liquid sealant such as Loctite™ 567 or equivalent.



**Figure #4**

#### **Connecting the Throttle:**

- 5) The throttle lever (L1-12-1) can be installed on either side of the throttle body, at any angle. The throttle shaft can rotate  $75^{\circ}$  from completely closed to wide open. No matter how you orient the throttle lever to the shaft, you can always tell whether the throttle is closed or open by looking at the scribed line on the end of the throttle shaft (see figure #5). This line matches the angle of the throttle fly. For instance, in figure #5 the throttle is closed.



**Figure #5**

- 6) Set the governor or throttle control for a closed throttle position. Rotate the throttle shaft to the low idle position.

**NOTE:** On generator installations, it is suggested to set the idle stop screw so that the throttle plate is  $5^{\circ}$  to  $10^{\circ}$  open to prevent the governor from undershooting when the generator unloads. Once you have the carburetor properly adjusted, you can adjust the idle stop screw to fine tune the low idle speed. This should improve stability.

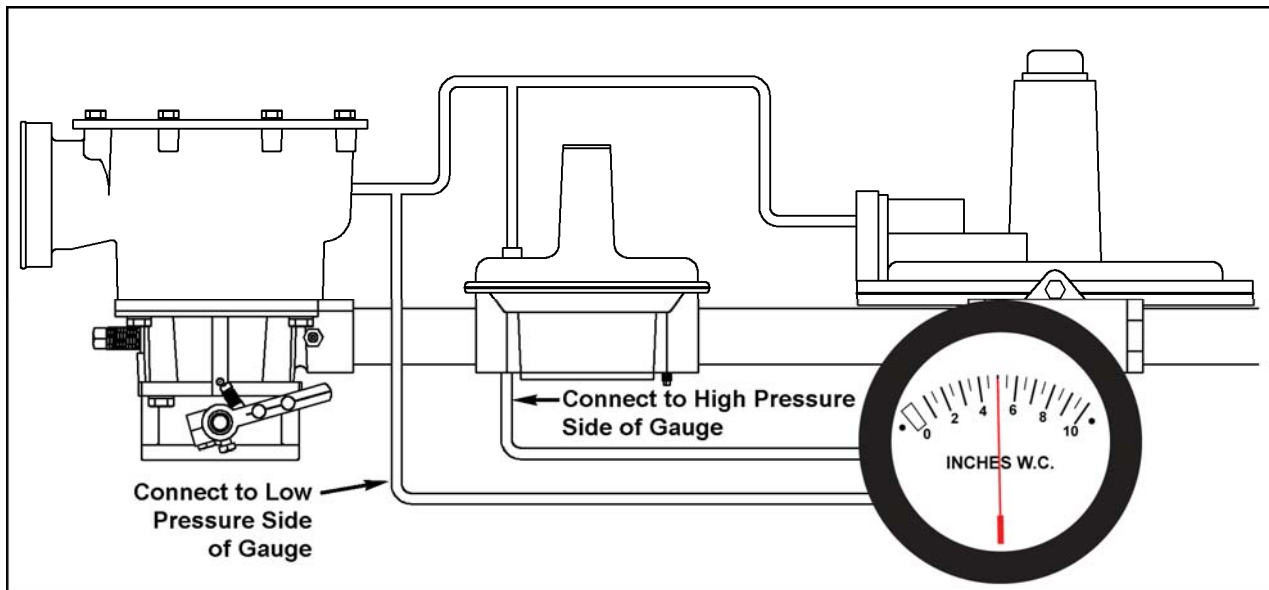
- 7) Install the throttle lever on the shaft, and connect the throttle linkage. This installation will vary depending on the type of throttle control you are using. After the linkage is in place, make sure the throttle shaft is still in the closed position. Once you have aligned the throttle shaft and the governor, you can tighten the clamping bolt on the throttle lever to 60 in-lb.



## Adjusting the 400VF3 Carburetor:

NOTE: For more information on adjusting VARIFUEL carburetors, refer to *VARIFUEL Carburetor Adjusting and Maintenance*.

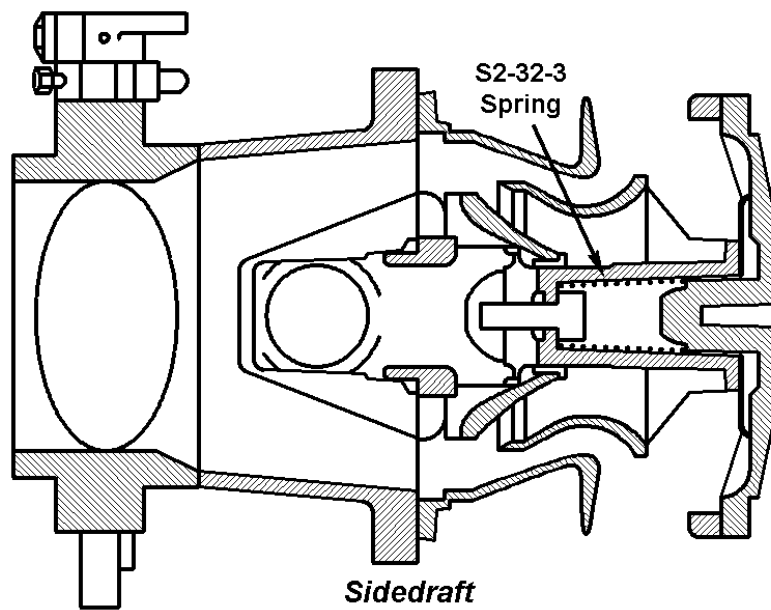
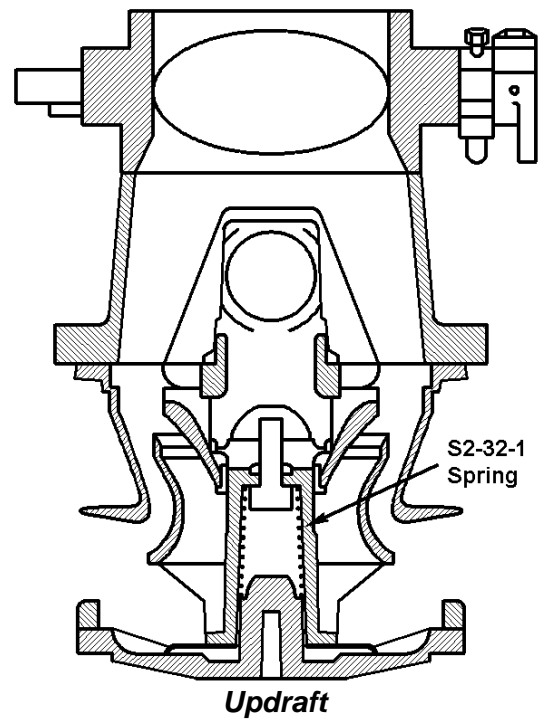
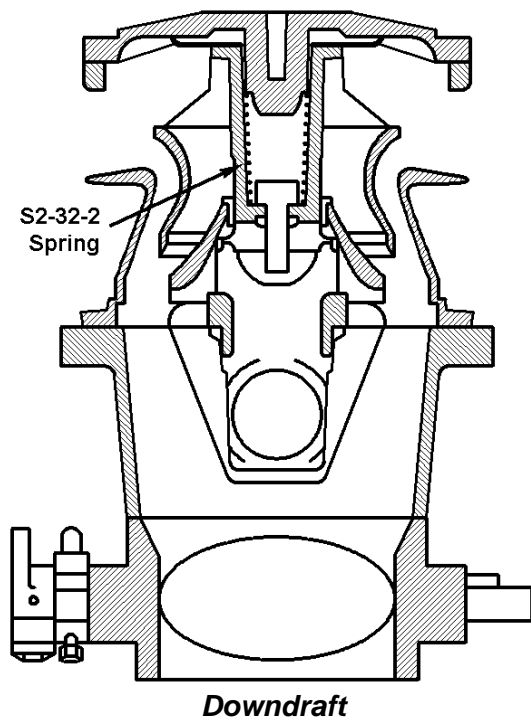
- 8) Locate the power-adjust screw on the carburetor (large, hex head, spring loaded screw directly opposite of the fuel inlet). Tighten the screw until the spring is fully compressed, then loosen it five (5) full turns. This is a good starting point and should **only be adjusted further with the engine running under full load**.
- 9) Before performing this step, make sure the main regulator is adjusted correctly. Refer to *Adjusting Main and Sub-Regulators* in the *Pressure Regulators* section. Measure the pressure differential between the outlet side of the sub-regulator and the balance line. Make the gauge connections as illustrated in figure #6. Run the engine at fast idle (rated speed, no load), and adjust the sub-regulator so the gauge reads 5 inches H<sub>2</sub>O column.



**Figure #6**

- 10) Run the engine under full load. The fuel pressure should not drop below 3.5 inches H<sub>2</sub>O column. If it does, refer to *VARIFUEL Carburetor Adjusting and Maintenance* in this section and verify the engine will achieve maximum power. If it will not, then there are too many restrictions in the fuel supply line network or the sub-regulator is too small.
- 11) The carburetor can be adjusted for maximum power, best fuel economy, or lowest emissions depending on your requirements. This is accomplished by turning the power-adjust screw (engine at full load) in to lean the mixture and out to richen the mixture. Refer to *VARIFUEL Carburetor Adjusting and Maintenance* for information.

NOTE: The power-adjust screw has minimal affect on starting or idling performance, unless it is completely closed.



**600VF3 Installation Orientations**

## B. 600VF3

### Introduction:

The VARIFUEL 600VF3 was designed to be a bolt-on replacement for the IMPCO 200T or the IMPCO 600 carburetor. However, the 600VF3 (as with all VARIFUEL carburetors) allows you to change its internal gas valves and jets to accommodate different fuel types and air/fuel ratios. Also, you can fine tune the air/fuel ratio by adjusting the fuel pressure and power-adjust screw. Figure #7 is the 200T and figure #8 is the 600VF3. Notice that the fuel inlet on the 600VF3 is in a different position than the 200T. This illustration of the 600VF3 shows the fuel inlet facing the camera, 90° to the air horn inlet and throttle shaft. However, the fuel inlet (part of the Gas Inlet Module) can be rotated to four different positions in relation to the air horn and throttle body.



**Figure #7**



**Figure #8**

### Mounting Options:

The VARIFUEL 600VF3 carburetor can be mounted in a downdraft, updraft or sidedraft configuration. Referring to the illustrations on the facing page, the updraft installation has the throttle body on top and the downdraft has the throttle body on the bottom. Note the part number for the air valve spring on the different illustrations. The downdraft spring (S2-32-2) is yellow, the updraft spring (S2-32-1) is silver, and the sidedraft spring (S2-32-3) is green. There are two special springs for updraft installations on turbocharged engines. The two springs are red (S2-41), and blue (S2-123) (consult your local IMPCO distributor for more information). If the installation orientation needs to be changed, then the proper spring will have to be installed.

Additionally, the different modules can be installed at 90° increments to one another. Starting with the throttle body, it can be rotated in 90° increments to the intake manifold giving you four different positions in which to line-up the throttle arm to the governor (and clockwise or counter-clockwise throttle rotation). Also, the gas inlet can be rotated in 90° increments to the throttle body with a resultant four different positions. Finally, the 90° air

horn (AA2-16) can be rotated in 90° increments, or can be replaced with the straight in-line air horn (AA2-22). This allows for five different orientations for installation to the intake hose.

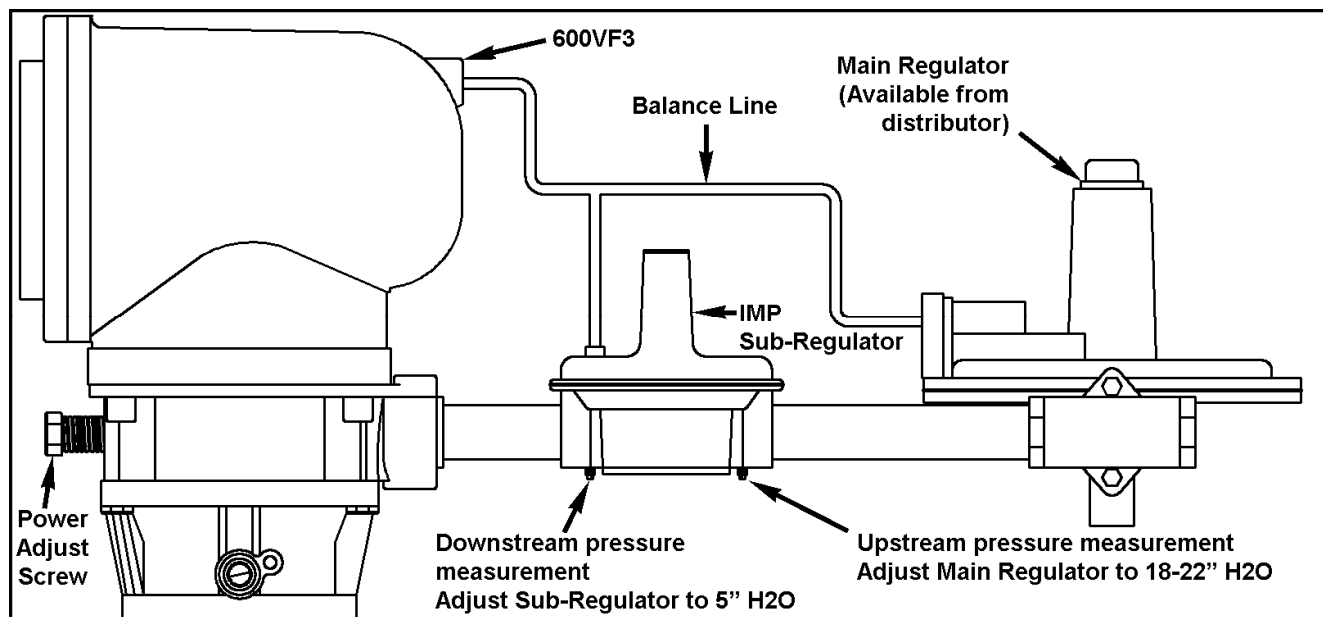
The following installation instructions are tailored to the standard downdraft installation. In this installation, the throttle body is on the bottom and the air horn is on top. If your installation is going to position the carburetor in an updraft or sidedraft position, reverse the references for the updraft installation, or change to left and right for the sidedraft installation (as warranted).

### **Installing the 600VF3 Carburetor:**

If the carburetor was not assembled by your distributor (or the module orientations need to be changed), then decide how each module will orient themselves to one another. Trial fit the modules in place on the intake manifold. Mark their orientations to each other with a felt marker across the mating surfaces. DO NOT remove the Mixer Module from the Gas Inlet Module. Also, it is not advisable to assemble the carburetor on the engine. Start by assembling the carburetor in the following sequence:

- 1) First, install the Gas Inlet Module to the Mixture Outlet Module (throttle body) with the orientation markings lined up. Place a new gasket (G1-78) on top of the Mixture Outlet Module and install the Gas Inlet Module with four 3/8"-16 x 1" hex bolts. DO NOT use any sealant on the gasket. Tighten the bolts evenly in a cross pattern to 10 in-lb, then finish torquing to 29-36 ft-lbs in the same cross pattern.
- 2) You will now be installing the carburetor (minus Air Inlet Module) onto the intake manifold. Place a new gasket (G1-38 for 4" flange, G1-29 for 3 1/2" flange) in place on the clean intake manifold. DO NOT use any gasket sealant as some fuels can break down different sealant compounds. As long as all mounting surfaces are clean and flat, there should be no problems with gaskets sealing properly. Place the carburetor over the gasket and install it using four 1/2" bolts. Tighten the bolts evenly in a cross pattern to 10 in-lb, then finish torquing to 40 ft-lb in the same cross pattern.
- 3) Next, install the Air Inlet Module. Place a new gasket (G1-76-1) on top of the Gas Inlet Module (around the Mixer Module). Again, DO NOT use any sealant. Position the Air Inlet Module (in the correct orientation) and slide it down over the Mixer Module. Install the four 3/8"-16 x 1" hex bolts. Tighten the bolts evenly in a cross pattern to 10 in-lb, then finish torquing to 29-36 ft-lbs in the same cross pattern.

## Installing the Fuel System:

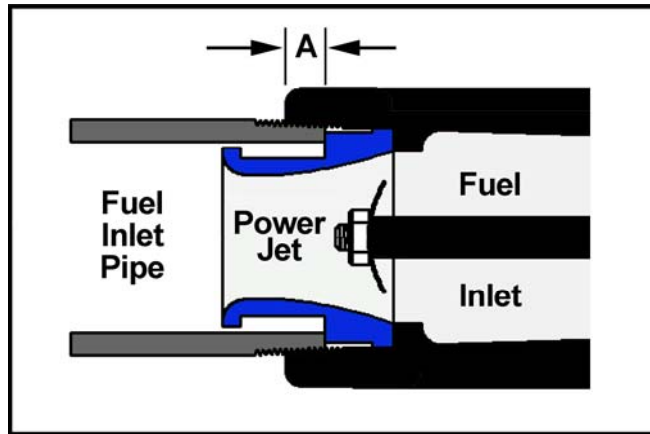


**Figure #9**

The gas valves in the 600VF3 are designed for a constant fuel inlet pressure of 5" H<sub>2</sub>O (measured with engine running at fast idle). For this reason, the fuel pressure regulator should be located close to the sub-regulator, with as few elbows as possible to keep fuel flow restriction at a minimum (45° elbows are preferred over 90° elbows). The correct installation requires a regulator and sub-regulator (see figure #9). In this case, the main regulator produces around 20" H<sub>2</sub>O fuel pressure, and the sub-regulator (located within two feet of the carburetor) delivers 5" H<sub>2</sub>O fuel pressure to the carburetor. For more information on installing regulators and sub-regulators, refer to *Installing Regulators and Sub-Regulators* in the *Pressure Regulators* section.

Follow these directions for the fuel system connections:

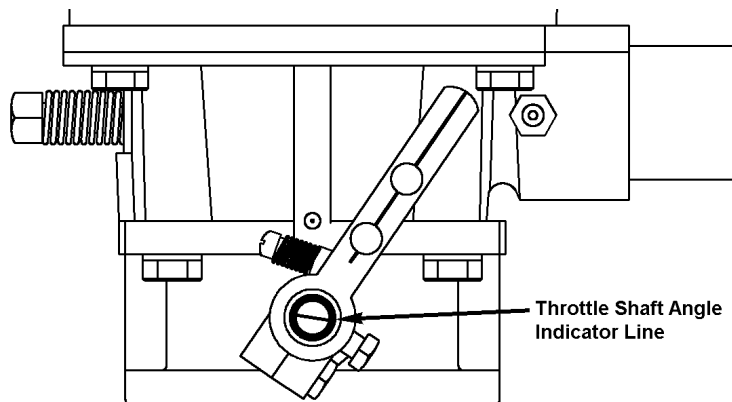
- 4) Connect the fuel line to the carburetor. If you are replacing an IMPCO 200T, then you may need to reroute the fuel pipes and regulator as the 600VF3 has a different fuel inlet location than the 200T. Use 1 1/2" NPT pipe (refer to your local code for correct type). Note that the pipe threads into the Gas Inlet Module body and fits around the aluminum power jet in the fuel inlet. Also, the pipe compresses against the flange on the power jet locking it into the gas inlet (see figure #10). Before installing the pipe, (using a pocket ruler) measure the distance from the outside face of the fuel inlet to the flange face of the power jet (measurement "X" on figure #10). Mark the fuel pipe the same distance from the end with a felt pen. The pipe should be tightened securely. However, if the torque required to tighten the pipe suddenly increases sharply, the end of the pipe has probably seated against the jet boss and should not be tightened any further. DO NOT over-torque or under-torque the pipe. If it will not reach the mark without over-torquing, then remove the pipe and cut a few more threads with the appropriate NPT die. If it bottoms out without adequate torque to seal the threads, try another section of pipe or cut 1/8"- 3/16" from the end of the pipe. DO NOT use Teflon™ tape on pipe threads. Use a liquid sealant such as Loctite™ 567 or equivalent.



**Figure #10**

### Connecting the Throttle:

- 4) The throttle lever (L1-12-1) can be installed on either side of the throttle body, at any angle. The throttle shaft can rotate  $75^{\circ}$  from idle to wide open. No matter how you orient the throttle lever to the shaft, you can always tell whether the throttle is closed or open by looking at the scribed line on the end of the throttle shaft (see figure #11). This line matches the angle of the throttle fly. For instance, in figure #11 the throttle is closed.



**Figure #11**

- 5) Set the governor or throttle control for a closed throttle position. Rotate the throttle shaft to the low idle position.

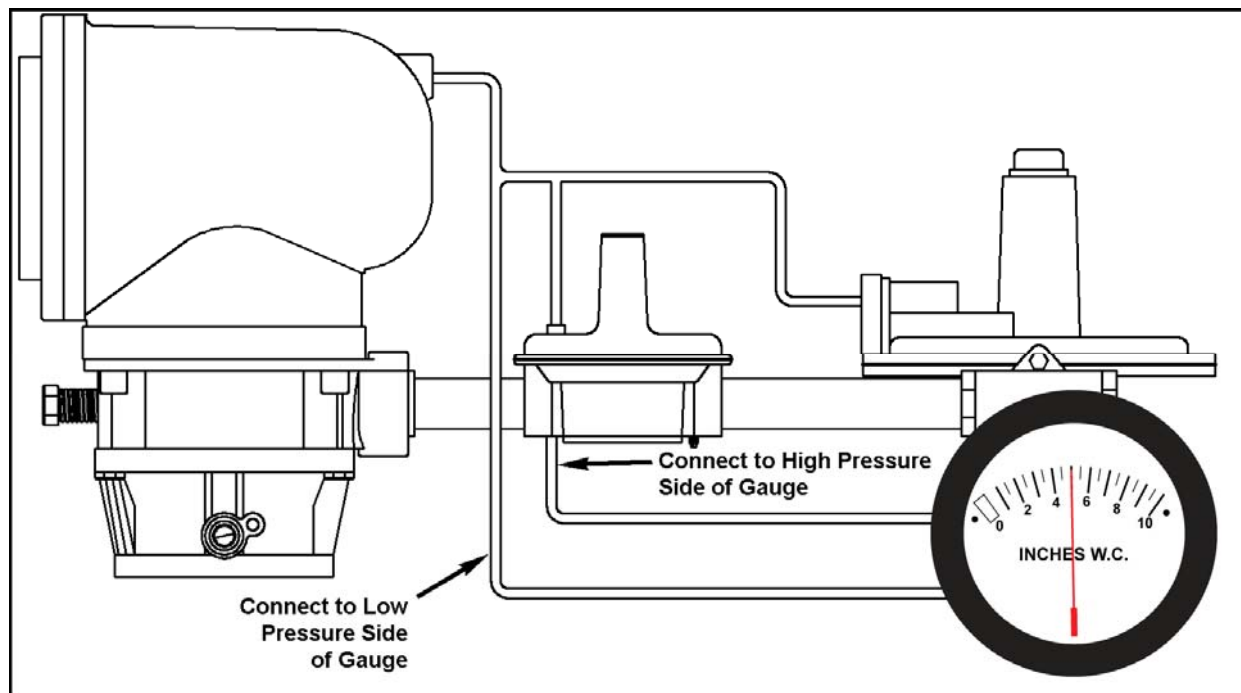
NOTE: On generator installations, it is suggested to set the idle stop screw so that the throttle plate is  $5^{\circ}$  to  $10^{\circ}$  open to prevent the governor from undershooting when the generator unloads. Once you have the carburetor properly adjusted, you can adjust the idle stop screw to fine tune the low idle speed. This should improve stability.

- 6) Install the throttle lever on the shaft, and connect the throttle linkage. This installation will vary depending on the type of throttle control you are using. After the linkage is in place, make sure the throttle shaft is still in the closed position. Once you have aligned the throttle shaft and the governor, you can tighten the clamping bolt on the throttle lever to 60 in-lb.

## Adjusting the 600VF3 Carburetor:

NOTE: For more information on adjusting VARIFUEL carburetors, refer to *VARIFUEL Carburetor Adjusting and Maintenance* in this section.

- 7) Locate the power-adjust screw on the carburetor (large, hex head, spring loaded screw directly opposite of the fuel inlet). Tighten the screw until the spring is fully compressed, then loosen it five (5) full turns. This is a good starting point and should **only be adjusted further with the engine running under full load.**
- 8) Before performing this step, make sure the main regulator is adjusted correctly. Refer to *Adjusting Main and Sub-Regulators* in the *Pressure Regulators* section. Measure the pressure differential between the outlet side of the sub-regulator and the balance line. Make the gauge connections as illustrated in figure #12. Run the engine at fast idle (rated speed, no load), and adjust the sub-regulator so the gauge reads 5 inches H<sub>2</sub>O column.

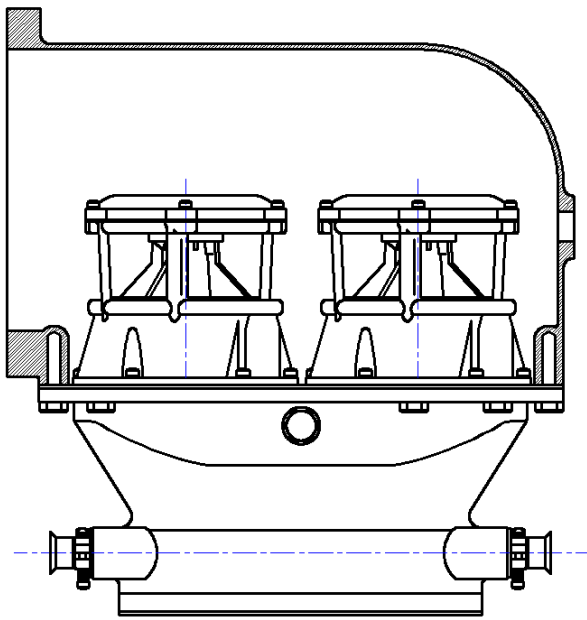


**Figure #12**

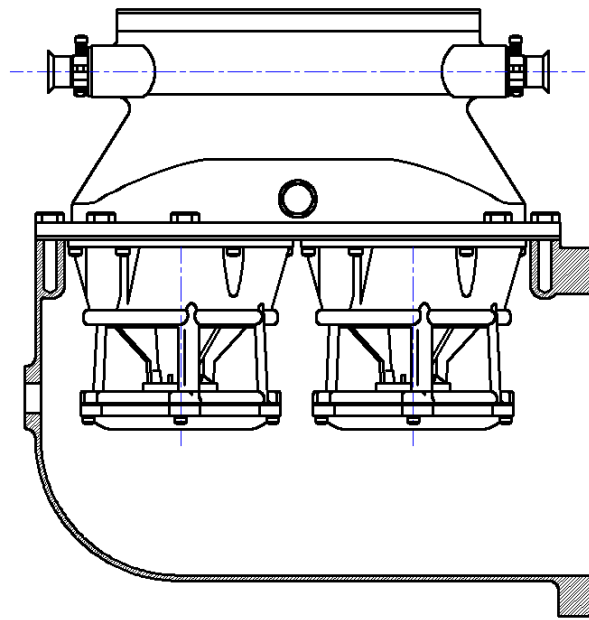
- 9) Run the engine under full load. The fuel pressure should not drop below 3.5 inches H<sub>2</sub>O column. If it does, refer to *VARIFUEL Carburetor Adjusting and Maintenance* in this section and verify the engine will achieve maximum power. If it will not, then there are too many restrictions in the fuel supply line network or the sub-regulator is too small.
- 10) The carburetor can be adjusted for maximum power, best fuel economy, or lowest emissions depending on your requirements. This is accomplished by turning the power-adjust screw (engine at full load) in to lean the mixture and out to richen the mixture. Refer to *VARIFUEL Carburetor Adjusting and Maintenance* for information.  
NOTE: The power-adjust screw has no affect on starting or idling performance



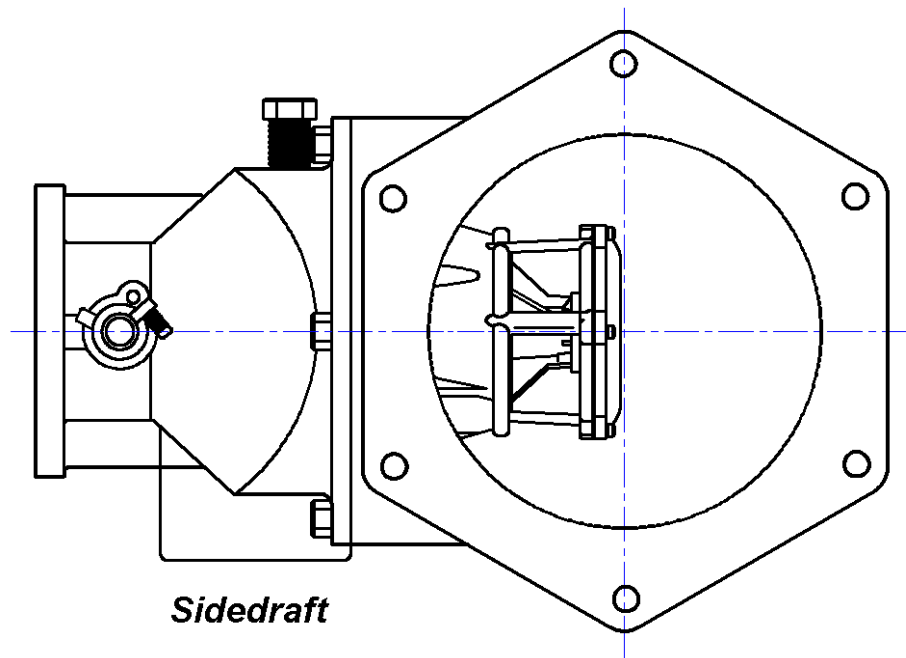




***Downdraft***



***Updraft***



***Sidedraft***

***600VF3D Installation Orientations***

## C. 600VF3D

### Introduction:

The VARIFUEL 600VF3D was designed to be a bolt-on replacement for the IMPCO 600D. However, the 600VF3D (as with all VARIFUEL carburetors) allows you to change its internal gas valves and jets to accommodate different fuel types and air/fuel ratios. The “D” in the 600VF3D part number designates this as a “Duplex” carburetor. This means there are two VARIFUEL 600VF3 Mixer Modules in the carburetor.

### Mounting Options:

The VARIFUEL 600VF3D carburetor can be mounted in a downdraft, updraft or sidedraft configuration. Referring to the illustrations on the facing page, the updraft installation has the throttle body on top and the downdraft has the throttle body on the bottom. Note the part number for the air valve spring on the different illustrations. The downdraft spring (S2-32-2) is yellow, the updraft spring (S2-32-1) is silver, and the sidedraft spring (S2-32-3) is green. There are two special springs for updraft installations on turbocharged engines. The two springs are red (S2-41), and blue (S2-123). Consult your local IMPCO distributor for more information. If the installation orientation needs to be changed, then the proper spring will have to be installed.

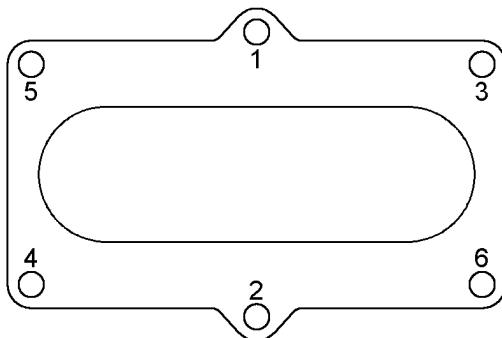
Additionally, the different modules can be installed at 180° increments to one another. Starting with the throttle body, it can be rotated in 180° increments to the intake manifold giving you two different positions in which to line-up the throttle arm to the governor (and clockwise or counter-clockwise throttle rotation). Also, there are 3 different Air Inlet Modules (Air Horn) available. The 90° air horn (end inlet, AA2-62) can be rotated 180°, the 90° air horn (side inlet, AA2-18) can be rotated 180° or you can select one of the straight in-line air horns. This allows for five different orientations for installation to the intake hose.

The following installation instructions are tailored to the standard downdraft installation. In this installation, the throttle body is on the bottom and the air horn is on top. If your installation is going to position the carburetor in an updraft or sidedraft position, reverse the references for the updraft installation, or change to left and right for the sidedraft installation (as warranted). The instructions are for installing the carburetor without an intake manifold adapter (such as used on Ingersoll-Rand 8, 10 and 12 SVGs). If an adapter is being used, make sure to orient the adapter correctly and install it with new gaskets.

## Installing the 600VF3D Carburetor:

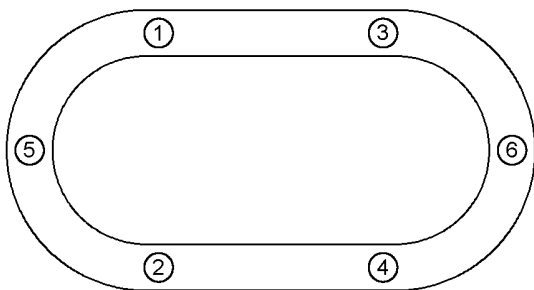
If the carburetor was not assembled by your distributor (or the module orientations need to be changed), then decide how each module will orient themselves to one another. Trial fit the modules in place on the intake manifold. Mark their orientations to each other with a felt marker across the mating surfaces. **DO NOT** remove the Mixer Modules from the Mixture Outlet Module. Install the carburetor in the following sequence:

- 1) First, install the Mixture Outlet Module (throttle body/gas inlet) to the intake manifold. Place a new gasket (G1-80) on top of the intake manifold and install the Mixture Outlet Module with six 1/2" hex bolts. **DO NOT** use any gasket sealant as some fuels can break down different sealant compounds. As long as all mounting surfaces are clean and flat, there should be no problem with gaskets sealing properly. Tighten the bolts evenly in a cross pattern (see figure #13) to 10 in-lb, then finish torquing to 40 ft-lb in the same cross pattern.

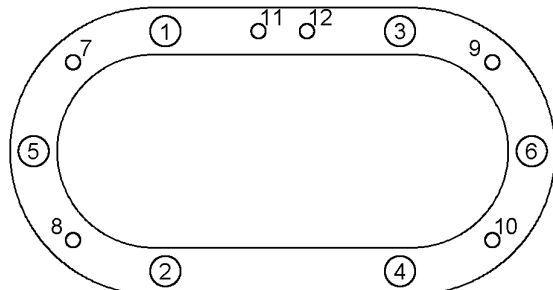


**Figure #13**

- 2) Start all Air Horn bolts before tightening to 10 in-lbs in the illustrated sequences (see figures 14 & 14A). Finish tightening them to the following torque values in the same sequences:
  - A. 1/4"-20: 90-110 in-lbs.
  - B. 3/8"-16: 29-36 ft-lbs.

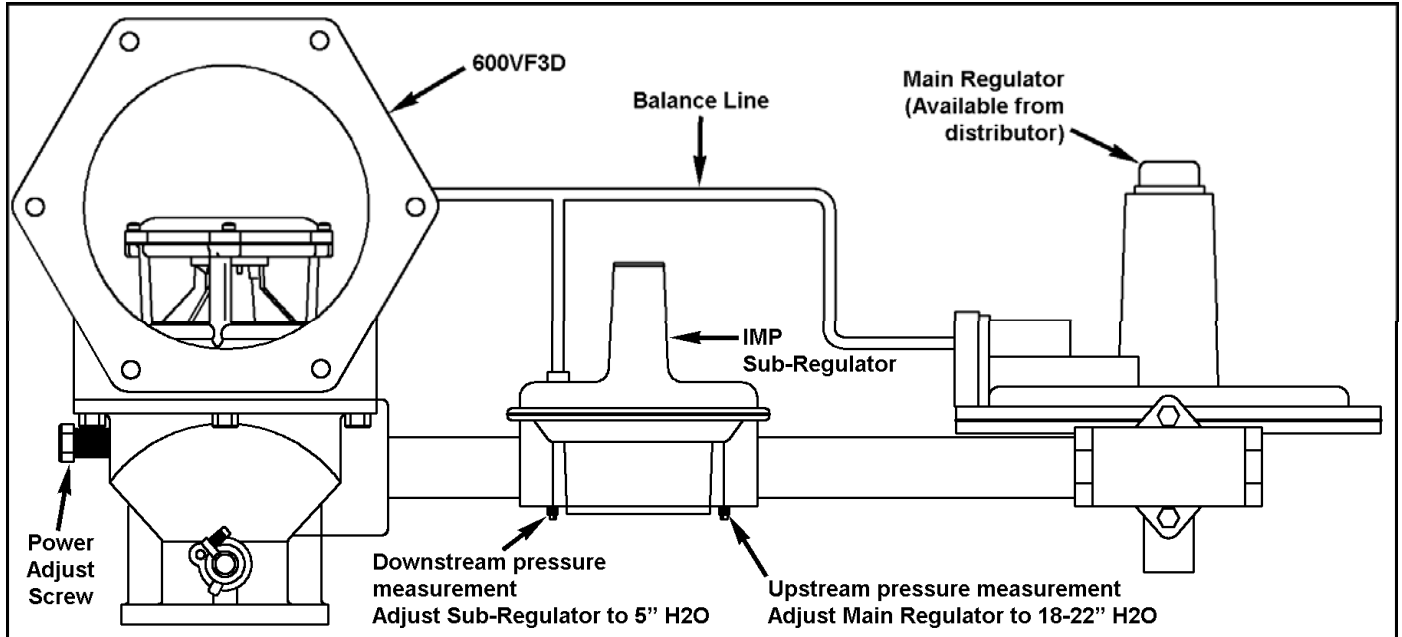


**Figure #14**



**Figure #14A**

## Installing the Fuel System:



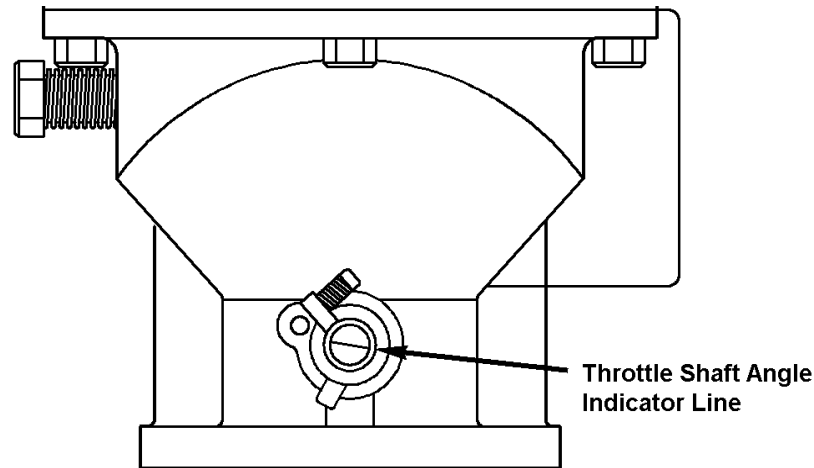
**Figure #15**

The gas valves in the 600VF3D are designed for a constant fuel inlet pressure of 5" H<sub>2</sub>O (measured with engine running at fast idle). For this reason, the fuel pressure regulator should be located close to the sub-regulator, with as few elbows as possible to keep fuel flow restriction at a minimum (45° elbows are preferred over 90° elbows). The correct installation requires a regulator and sub-regulator (see figure #15). In this case, the main regulator produces around 20" H<sub>2</sub>O fuel pressure, and the sub-regulator (located within two feet of the carburetor) delivers 5" H<sub>2</sub>O fuel pressure to the carburetor. For more information on installing regulators and sub-regulators, refer to *Installing Regulators and Sub-Regulators* in the *Pressure Regulators* section.

Follow these directions for the fuel system connections

- 3) Connect the fuel line to the carburetor. Use 2" NPT (refer to your local code for correct type). DO NOT use Teflon™ tape on the pipe threads. Use a liquid sealant such as Loctite 567™ or equivalent.

- 4) The throttle lever (L1-12-1) can be installed on either side of the throttle body, at any angle. The throttle shaft can rotate  $75^{\circ}$  from idle to wide open. No matter how you orient the throttle lever to the shaft, you can always tell whether the throttle is closed or open by looking at the scribed line on the end of the throttle shaft (see figure #16). This line matches the angle of the throttle fly. For instance, in figure #16 the throttle is closed.



**Figure #16**

- 5) Set the governor or throttle control for a closed throttle position. Rotate the throttle shaft to the low idle position.

NOTE: On generator installations, you will probably want to set the idle stop screw so that the throttle plate is  $5^{\circ}$  to  $10^{\circ}$  open. This will prevent the governor from undershooting when the generator unloads. Once you have the carburetor properly adjusted, you can adjust the idle stop screw to fine tune the low idle speed. This should improve stability.

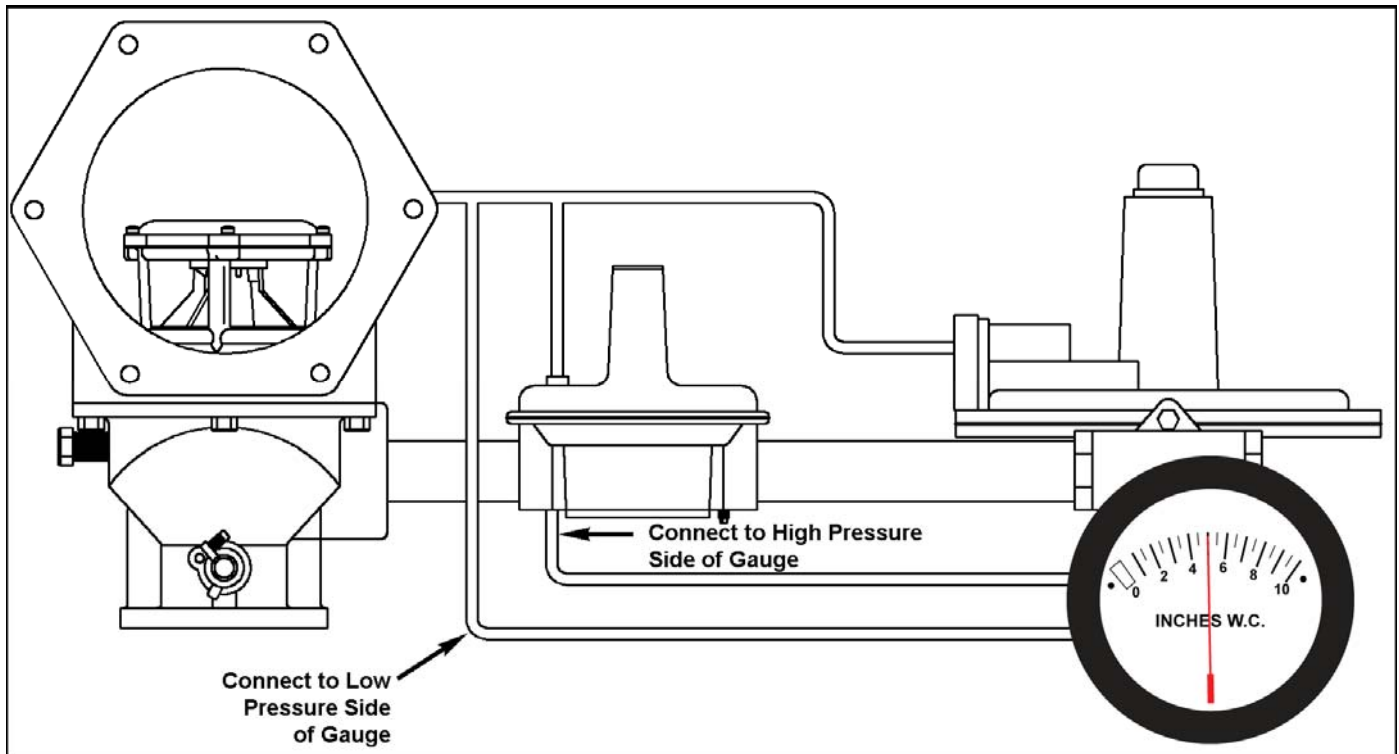
- 6) Install the throttle lever on the shaft, and connect the throttle linkage. This installation will vary depending on the type of throttle control you are using. After the linkage is in place, make sure the throttle shaft is still in the closed position. Once you have aligned the throttle shaft and the governor, you can tighten the clamping bolt on the throttle lever to 60 in-lb.

### **Adjusting the 600VF3D Carburetor:**

NOTE: For more information on adjusting VARIFUEL carburetors, refer to *VARIFUEL Carburetor Adjusting and Maintenance* in this section

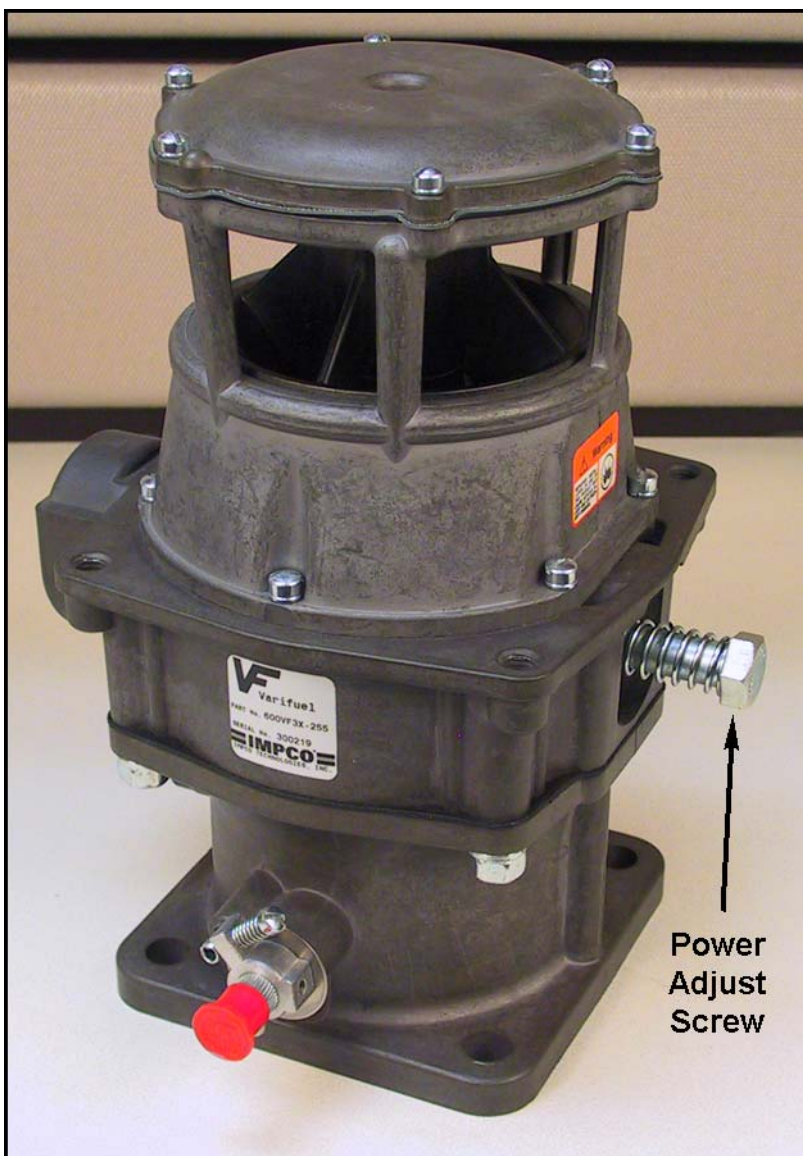
- 7) Locate the power-adjust screw on the carburetor (large, hex head, spring loaded screw directly opposite of the fuel inlet). Tighten the screw until the spring is fully compressed, then loosen it five (5) full turns (never loosen the screw by more than 10 turns from fully seated). This is a good starting point and should ***only be adjusted further with the engine running under full load.***

- 8) Before performing this step, make sure the main regulator is adjusted correctly. Refer to *Adjusting Main and Sub-Regulators* in the *Pressure Regulators* section. Measure the pressure differential between the outlet side of the sub-regulator and the balance line. Make the gauge connections as illustrated in figure #17. Run the engine at fast idle (rated speed, no load), and adjust the sub-regulator so the gauge reads 5 inches H<sub>2</sub>O column.



**Figure #17**

- 9) Run the engine under full load. The fuel pressure should not drop below 3.5 inches H<sub>2</sub>O column. If it does, refer to *VARIFUEL Carburetor Adjusting and Maintenance* in this section and verify the engine will achieve maximum power. If it will not, then there are too many restrictions in the fuel supply line network or the sub-regulator is too small.
- 10) The carburetor can be adjusted for maximum power, best fuel economy, or lowest emissions depending on your requirements. This is accomplished by turning the power-adjust screw (engine at full load) in to lean the mixture and out to richen the mixture. Refer to *VARIFUEL Carburetor Adjusting and Maintenance* for information.
- NOTE: The power-adjust screw has no affect on starting or idling performance.



**Figure #18**

**VARIFUEL 600VF3 Illustrated**



# **VARIFUEL Carburetor Adjusting and Maintenance**

## **Adjusting the VARIFUEL Carburetor**

The power adjust screw on the VARIFUEL carburetor sets the air/fuel mixture for the engine under medium and heavy loads. It is the hex-head screw (with a spring on it) located on the lower half of the carburetor, opposite of the fuel inlet (see figure #18). You should adjust this screw while the engine is running at full power, under load. All vacuum readings are based on sea level readings. Make adjustments to readings as necessary to compensate for altitude.

### **To Adjust for Maximum Power:**

Connect a manifold vacuum gauge to the intake manifold on the engine. Run the engine under full load, at maximum rated rpm. While monitoring the manifold vacuum, turn the power adjust screw for the highest vacuum reading.

### **To Adjust for Best Fuel Economy:**

With the engine running at full load and rated rpm, and the carburetor adjusted for maximum power, turn the power adjust screw IN until the vacuum gauge drops by 1" to 1.5" Hg. The engine is now set for best fuel economy.

### **To Adjust for Best Emissions:**

You will need to install an exhaust gas analyzer (such as the Infrared Industries FGA-5000). First, adjust the carburetor for maximum power. Keep the engine running under full load, and turn the power adjust screw in (clockwise) until the exhaust gas contains approximately 5 to 7% oxygen.

*Optional:* Tighten the power adjust screw even further, until the exhaust gas oxygen content reaches 8.5%. However, some engines may not run well at such a lean setting.

**NOTE:** A leaner air/fuel ratio will usually reduce the engine's power output, especially on naturally aspirated (non-turbocharged) engines. For some engines (in some situations), meeting emission standards can reduce the engine's power by up to one third. However, the position of the power adjust screw will not affect starting or idling performance.

## Lean Burn Operation

### Introduction:

Lean burn operation allows an engine to meet exhaust emission limits without an expensive catalytic converter. By keeping the air/fuel ratio between  $\lambda = 1.4$  and  $\lambda = 1.7$  (see figure #19), there is excess air in the combustion mixture, which reduces the peak combustion temperature, therefore producing less  $\text{NO}_x$ . In addition, less CO is produced.

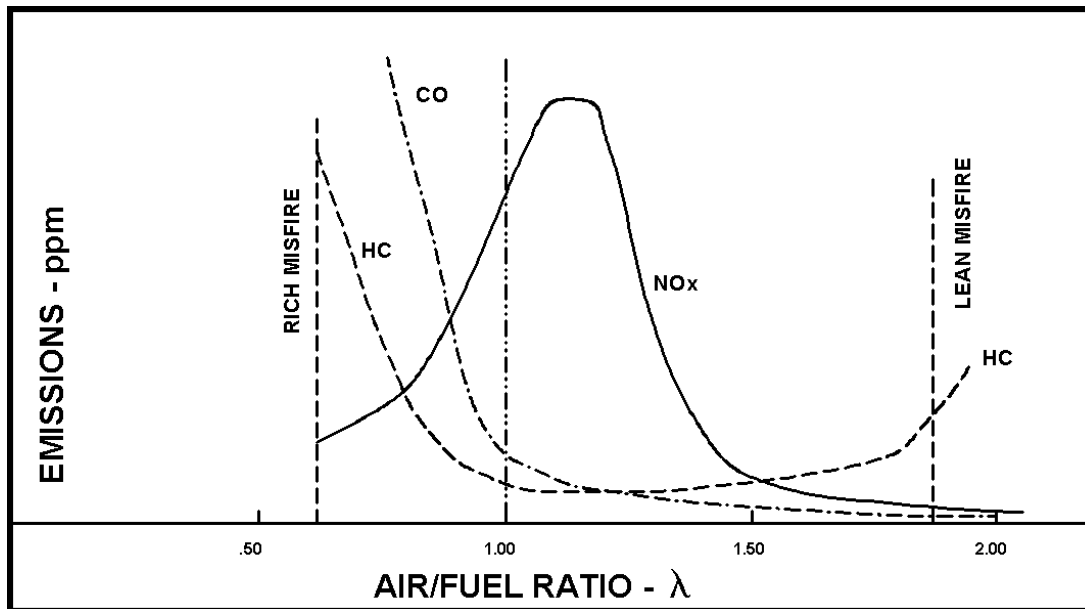


Figure #19

$\lambda$  1.00 = The Stoichiometric A/F Ratio

### Controlling the Air/Fuel Ratio (Fuel Pressure and Power Valve Position):

When the engine is starting and idling, there is very little air flowing through the carburetor. In this case, the air/fuel ratio is determined mainly by the fuel pressure coming from the regulator (or sub-regulator where installed). Lean burn gas valves for IMPCO carburetors are nominally designed for 5 inches  $\text{H}_2\text{O}$  fuel inlet pressure. You may need to vary this pressure by  $\pm 1.5$  inches  $\text{H}_2\text{O}$  to accommodate different engines and fuel characteristics.

When the engine is running at full load, adjusting the fuel pressure is counterproductive. Not only will such changes disrupt the starting and idling response, but they have only a small effect on the full-load air/fuel ratio. When the engine is running at full load, the air velocities through the carburetor are much higher than they are at idle. These high velocities create a vacuum, which *draws* fuel into the carburetor. This vacuum effect (called the Bernoulli Effect) is five to eight times stronger than the fuel pressure setting of the regulator. Under these higher-vacuum, higher-flow conditions, you control the air/fuel ratio mainly by adjusting the power valve. On IMPCO VARIFUEL stationary-engine carburetors, turning the power adjust screw IN (clockwise) will decrease the fuel inlet area, and LEAN the air/fuel mixture. We recommend that you turn the power adjust screw in increments of one-half turn or less.

## Effects of Temperature:

The air/fuel ratio varies with the temperature of the incoming air. The carburetor alone cannot compensate for different air temperatures. For this reason, you should avoid pushing the lean misfire limit, because when the temperature changes, the engine could cross that limit. Likewise, you should avoid the engine's detonation limit (as discussed later). We recommend that you set the power adjust screw at least one half turn away from the lean misfire limit and the detonation limit. If these two limits are less than one turn apart, you may need a custom gas valve.

The best way to keep control of the air/fuel ratio is to regulate the temperature of the air going into the carburetor. On turbocharged engines, you can thermostatically control the temperature of the air leaving the aftercooler. The cooling system should be controlled by the aftercooler's outlet temperature; that is, the temperature of the air as it is going toward the carburetor.

In general, a leaner air/fuel ratio reduces the engine's peak power output, especially on naturally aspirated (non-turbocharged) engines. For some engines (in some situations), meeting emission standards can reduce the engine's power by up to one third. On turbocharged engines, you may need up to twice as much boost to compensate for this loss of power.

## Beware of Detonation:

With higher turbocharger boost levels, the risk of detonation increases. This risk is greatest as the engine operates closer to  $\lambda = 1.0$ . The exact detonation limit varies from engine-to-engine, and is highly dependent on fuel constituents (ethane, propane, etc.) and ignition timing.

As the mixtures become leaner, the detonation risk decreases, because the combustion process is diluted and slowed with excess air. This calls for an adjustment strategy that is opposite from most operators' previous experience. If detonation occurs, *lean the mixture* (turn the power adjust screw IN- clockwise). DO NOT richen the air/fuel ratio. Richening the mixture will increase detonation, which can crack pistons and valves, and could even break the crankshaft.

## Setting the Carburetor Power Adjust Screw:

In order to set the carburetor for lean burn operation, you will need to install an exhaust gas analyzer (such as the Infrared Industries FGA-5000).

Run the engine under normal load, and turn the power adjust screw IN (clockwise) until the exhaust gas contains approximately five to seven percent (5-7%) oxygen.

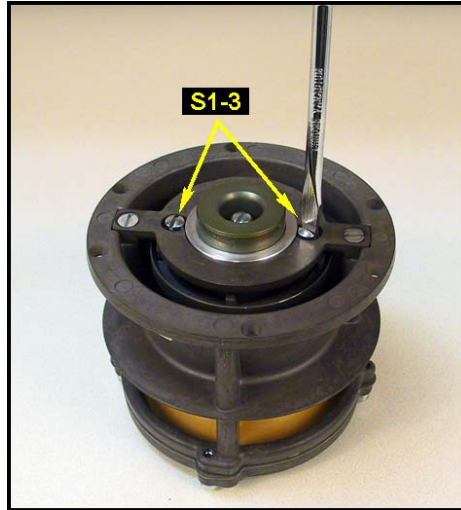
*Optional:* You can tighten the power adjust screw even farther, until the exhaust gas oxygen reaches 8.5%. However, some engines may not run well at such a lean setting.

**CAUTION:** Avoid operation in the lean range between 2.5% and 4.5% O<sub>2</sub>. Oil contamination is highly likely in this range and can lead to severe bearing, valve, piston, ring and liner damage.

## Changing the Gas Valve Jet Kit 400VF3:

### Disassembly:

- 1) Remove the Air Inlet Module (Air Horn) from the carburetor.
- 2) Remove the 6 screws holding the Mixer Module to the Gas Inlet Module and remove the mixer.
- 3) On the underside of the Mixer Module (Air Valve body) you will find two jet cover screws (S1-3 in figure #20). Loosen both of them a few turns.



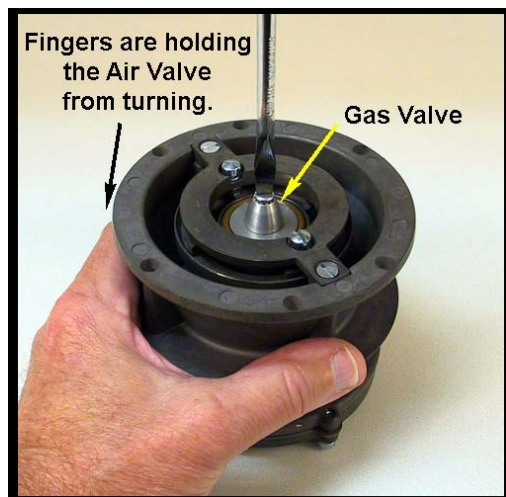
**Figure #20**

- 4) Now, remove the Gas Jet from the Air Valve body (you may have to use a pair of pliers).



**Figure #21**

- 5) Hold the Air Valve from twisting (within the Air Valve body) while you remove the Gas Valve screw (see figure #22).



**Figure #22**

- 6) Remove the Gas Valve and inspect the piston o-ring (S3-132) for wear or damage. Replace the o-ring where necessary.

### **Reassembly:**

1. Put the new V2 Gas Valve (Gas Valve part #s are marked on the flat side of the valve) on the stub shaft (S5-31). Keep the Air Valve from twisting (as in disassembly step #5) as you install and tighten the screw (S1-66) to 13-17 in-lbs. In rare cases, the stub shaft may slip and rotate as you turn the screw. If this happens, you will need to stop it from turning as follows:
  - A. Remove the four screws securing the Air Valve cover.
  - B. Remove the Air Valve cover and the spring beneath it. If the carburetor was installed in an updraft or sidedraft configuration, there will be a spacer under the spring. Turn the mixer over and remove the spacer (note the step in the spacer for the spring- this faces UP towards the cover when re-installed).
2. Use a 7/16" socket and extension to keep the stub shaft from turning while you tighten the Gas Valve retaining screw to 13-17 in-lbs (see figure #23).



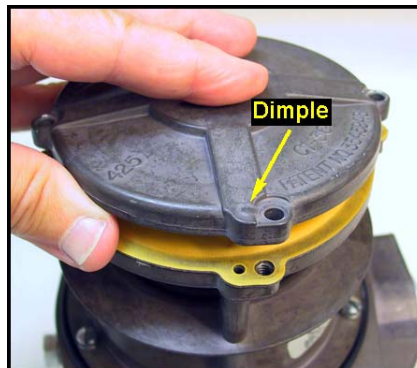
**Figure #23**

3. Reinstall the spring and spacer (where applicable- make sure the spacer is installed as in figure #24).



**Figure #24**

4. Reinstall the Air Valve cover. Be sure to align the vacuum port holes in all three pieces (see figure #25) and tighten the four screws evenly to 16-20 in-lbs.

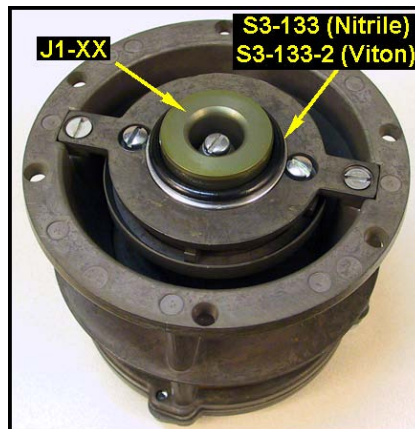


**Figure #25**

5. Insert the new Gas Jet into the Air Valve body (shoulder facing up). The jet should fit with the flange shoulder flush with the Air Valve body surface. Tighten the two jet holder screws (S1-3) evenly to 16-20 in-lbs (see figure #20).

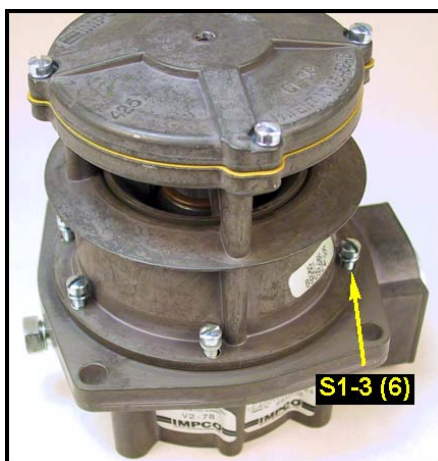
2. Lubricate the new Gas Jet o-ring with clean engine oil and slide it onto the new Gas Jet (see figure #26).

NOTE: The o-ring supplied with the new Gas Valve kit should be the correct one for your fuel type. Do not confuse the old and new o-rings. Natural gas applications use the Nitrile o-ring (S3-133) and landfill or digester gas applications use the Viton o-ring (S3-133-2).

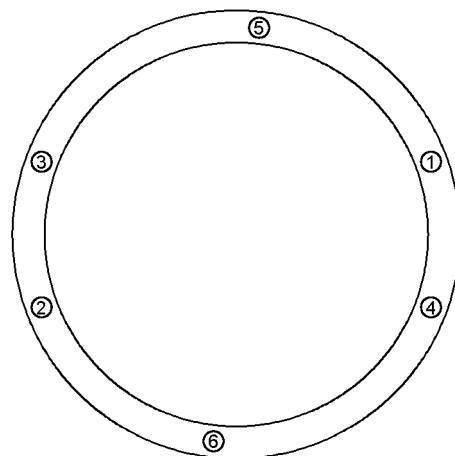


**Figure #26**

3. Carefully position the Mixer Module on the Gas Inlet Module. Start all six screws before tightening them evenly and in a diagonal sequence to 16-20 in-lbs (see figures #27 & 27A).



**Figure #27**



**Figure #27A**

4. Lightly lubricate (with clean engine oil) and install a new o-ring (S3-138) around the base of the Mixer Module (see figure #28).



**Figure #28**

5. Orient the Air Inlet Module (if 90° Air Horn is being used) as necessary and carefully slide it over the Mixer Module (being careful not to disturb the o-ring). Start all four 5/16" x 7/8" bolts into the Air Horn and tighten them evenly to 90-110 in-lbs.

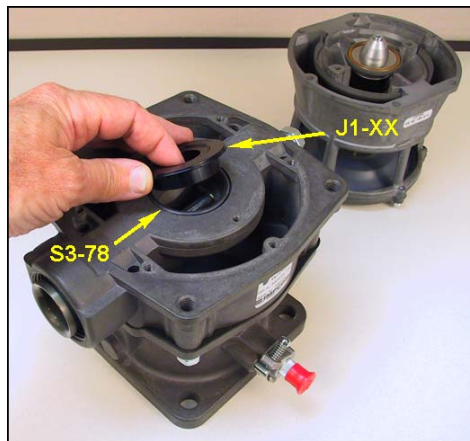


## 600VF3 and 600VF3D:

NOTE: The 600VF3D uses two 600VF3 Mixer Modules. The disassembly and reassembly steps between the 600VF3 and 600VF3D carburetors are similar. The instructions are tailored to the 600VF3 carburetor. Any noteworthy difference with the 600VF3D will be called out in the instructions.

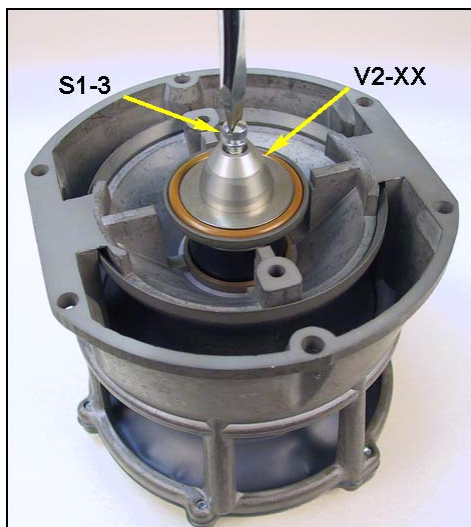
### Disassembly:

- 1) Remove the Air Inlet Module (Air Horn) from the carburetor.
- 2) Remove the six screws holding the Mixer Module to the Gas Inlet Module (600VF3D- Mixture Outlet Module) (Throttle Body) and remove the mixer.
- 3) Remove the J1 Gas Jet and o-ring (S3-78) from the Mixture Outlet Module (see figure #29).



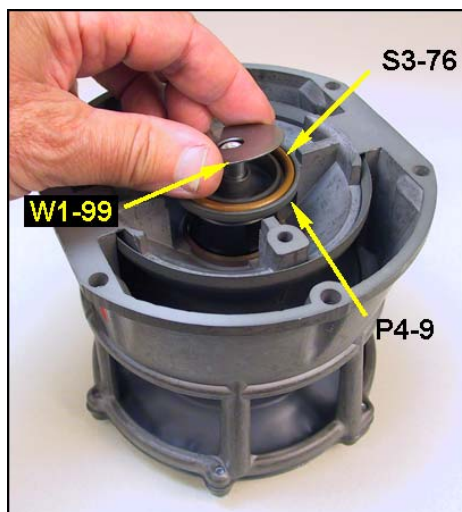
**Figure #29 (600VF3 Illustrated)**

- 4) Hold the Air Valve from twisting (within the Air Valve body) while you remove the Gas Valve screw (see figure #30).



**Figure #30**

- 5) Remove the Gas Valve and inspect the piston o-ring (S3-76) for wear or damage. Replace the o-ring where necessary (see figure #31).



**Figure #31**

## Reassembly

- 1) Install the new V2 Gas Valve onto the stub shaft (S5-29). Keep the Air Valve from twisting (as in disassembly step #4) while tightening the screw (S1-3) to 27-33 in-lbs.

NOTE: Gas Valve part numbers are marked on the flat side of most valves (see figure #32).



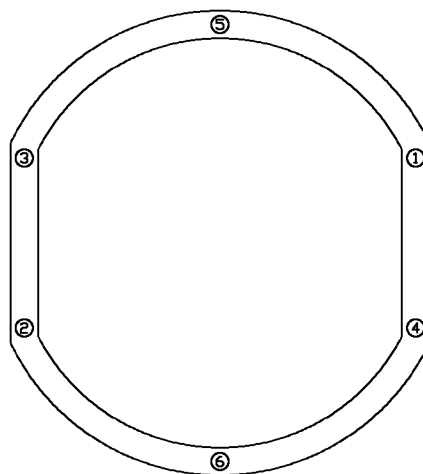
**Figure #32**

- 2) Lightly lubricate the Gas Jet o-ring (S3-78) and install on the J1 Gas Jet.
- 3) Install the Gas Jet/o-ring into the Gas Inlet Module (600VF3D-Mixture Outlet Module).

- 4) Orient the Mixer Module correctly and set it in place on the Gas Inlet Module (600VF3D–Mixture Outlet Module).
- 5) Make sure the Mixer Module is sitting squarely and flat against the Gas Inlet Module (600VF3D–Mixture Outlet Module). Start all six screws before tightening them to 27-33 in-lbs in a diagonal sequence (see figures #33 & 33A).

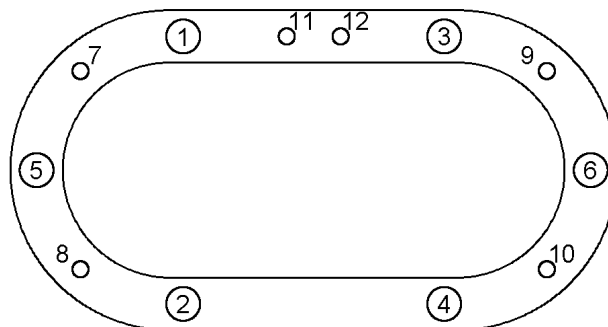
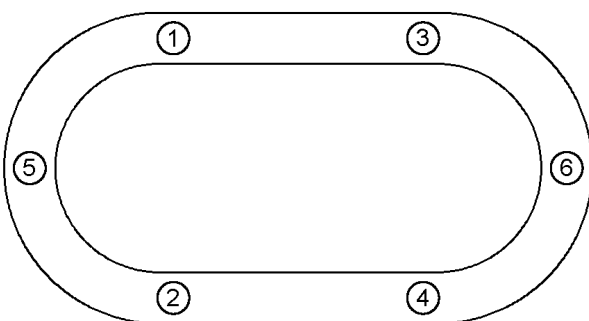


**Figure #33 (600VF3 Illustrated)**



**Figure #33A**

- 6) Set a new Air Horn gasket (part number dependent on model) in place around the Mixer Module(s). Orient the Air Horn correctly for your installation and carefully set it in place over the Mixer Module(s).
- 7) Start all Air Horn bolts before tightening to 10 in-lbs in the illustrated sequences. Finish tightening them to the following torque values in the same sequences:
  - A. 1/4"-20: 90-110 in-lbs.
  - B. 3/8"-16: 29-36 ft-lbs.



## Changing the Power Valve and Power Jet

### 400VF3 and 600VF3:

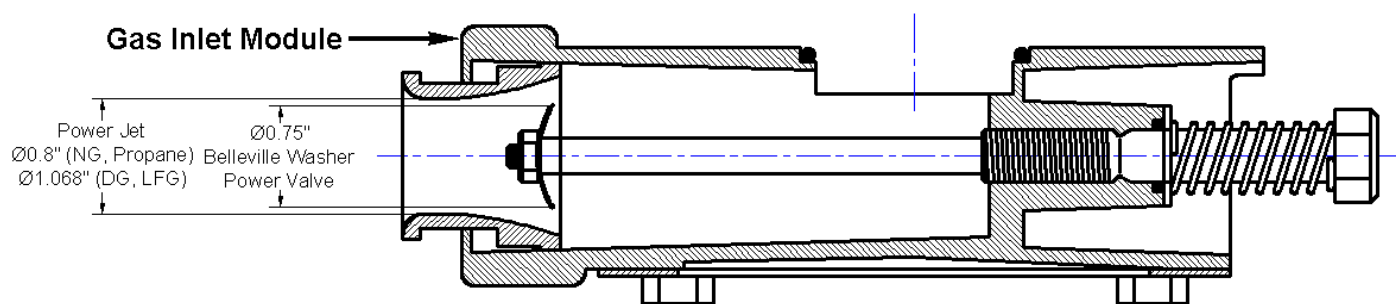
**NOTE:** The 600VF3D carburetor has a riveted in, fixed-plate Power Valve and no Power Jet.

The Power Valve and Power Jet control the volume of fuel entering the carburetor when the engine is under load. You may need to change the Power Valve and Power Jet to accommodate different types of fuel.

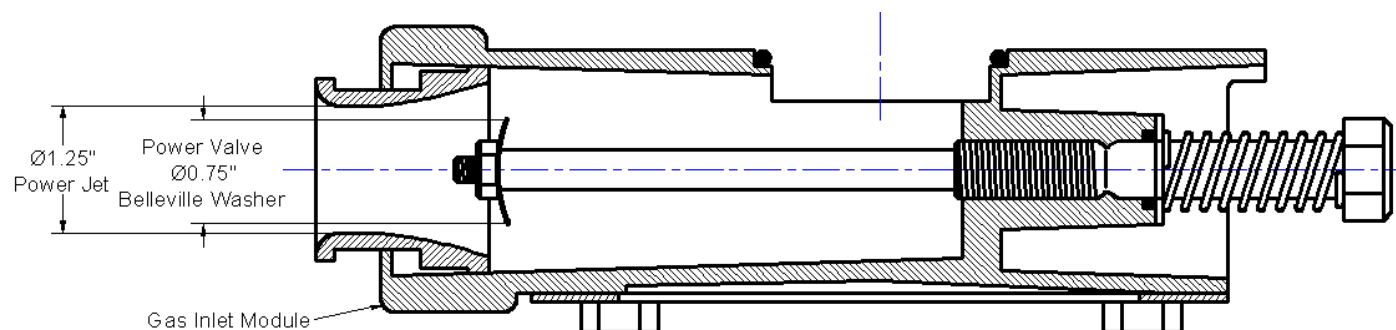
**NOTE:** If you are using propane or lean-burn NG at low rpm, you may wish to use a 400VF3 Mixer Module on a 600VF3 Gas Inlet Module and Mixture Outlet Module (Throttle Body). In this case, you will need to use an A3-128 adapter plate.

### Disassembly:

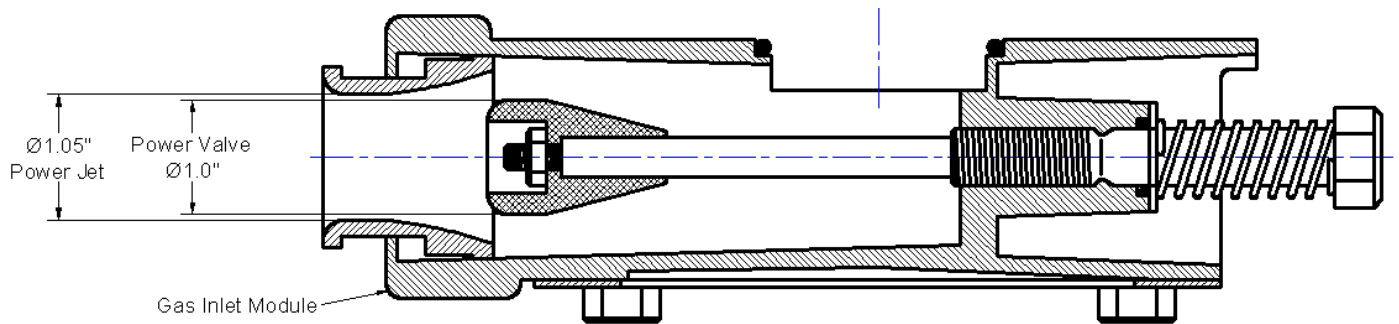
- 1) Close the fuel shut-off valve and bleed all fuel from the fuel line.
- 2) Remove the fuel line. You will need to access the port where the fuel line enters the carburetor (in the Gas Inlet Module). If necessary, remove the Gas Inlet Module and Mixer Module from the Mixture Outlet Module (Throttle Body).
- 3) If equipped, loosen the Power Jet set screw jam nut with a 3/8" wrench. Back the set screw off 2 to 3 turns with a 3/32" Allen wrench. Remove the Power Jet from the Gas Inlet Module.
- 4) Using an open-end or box-end wrench (9/16" for 400VF3, 3/4" for 600VF3), keep the Power Adjust Screw from turning while removing the Power Valve with a 7/16" socket (see figures 34 through 34B).



**Figure 34 (400VF3 Gas Inlet Module)**



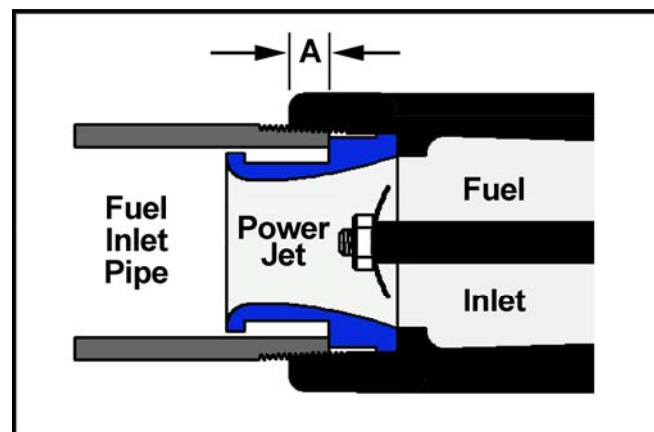
**Figure 34A (600VF3 Gas Inlet Module—Digester Gas or Landfill Gas)**



**Figure 34B (600VF3 Gas Inlet Module- NG or Propane)**

### Reassembly:

- 1) Install the new Power Valve onto the Power Adjust Screw. The Belleville washer used on the 400VF3 and the 600VF3 (DG, LFG applications) are installed with the concave side towards the screw (see figures 34 and 34A).
- 2) Install a new Nylock nut (N1-22) onto the Power Adjust Screw and tighten it to 38-42 in-lbs.
- 3) Referring to figures 34 through 34B, orient the Power Jet correctly and install it into the Gas Inlet Valve (seat it firmly and squarely in place by hand).
- 4) If you had to remove the Gas Inlet and Mixer Modules from the Throttle Body, reinstall them now with a new gasket.
- 5) Before reconnecting the fuel inlet pipe, (using a pocket ruler) measure the distance from the outside face of the fuel inlet to the flange face of the power jet (measurement "A" on figure #35). Mark the fuel pipe the same distance from the end with a felt pen. The pipe should be tightened securely. However, if the torque required to tighten the pipe suddenly increases sharply, the end of the pipe has probably seated against the jet boss and should not be tightened any further. DO NOT over-torque or under-torque the pipe. If it will not reach the mark without over-torquing, then remove the pipe and cut a few more threads with the appropriate NPT die. If it bottoms out without adequate torque to seal the threads, try another section of pipe or cut 1/8"- 3/16" from the end of the pipe. DO NOT use Teflon™ tape on pipe threads. Use a liquid sealant such as Loctite™ 567 or equivalent.



**Figure #35 (600VF3 Illustrated)**

- 6) Tighten the Power Jet set screw and jam nut.
- 7) After reconnecting the fuel line, check for leaks before opening the fuel shut-off valve.

NOTE: You will have to set the power adjust screw according to whatever emissions, power, and fuel economy needs you have. Always set the power adjust screw while the engine is running under load. Refer to *Adjusting the VARIFUEL Carburetor*.

## Recommended Service Parts

Following is a list of service parts for the IMPCO VARIFUEL carburetors. IMPCO recommends that you keep these parts in your inventory. These are the parts which wear during normal operation of the carburetors, and they are also the most likely to be damaged if an engine backfires.

### 400VF3:

#### Hard Parts:

Quantity (per Carb)	IMPCO Part Number	Description
1	D1-25	Diaphragm, silicone (yellow)
1	P2-62-2	Plate for diaphragm
1	B3-57	Upper guide bushing (brown)
1	B3-58	Lower guide bushing
1	V1-16	Air valve (anodized aluminum)
1	S1-12	Screws for diaphragm cover, #8-32 x 5/16" pan head SEMS

#### Gaskets:

Quantity (per Carb)	Gasket Part Number	Usage Description		
1	S3-138 (O-ring)	Air Inlet Module	To	Gas Inlet Module
1	G1-25-2 (Turbo)	Gas Inlet Module	To	Mixture Outlet Module
1	G1-25			
1	G1-27-2 (Turbo)	Mixture Outlet Module	To	Intake Manifold
1	G1-27			

**600VF3:****Hard Parts:**

Quantity (per Carb)	IMPCO Part Number	Description
1	RK-D1-20-3	Repair Kit, fluorosilicone diaphragm (blue). Includes plate, screws & upper anti-wear bushing.
1	B3-60	Lower guide bushing (brown)
1	V1-17	Air valve (anodized aluminum)
1	C1-32	Cover, diaphragm

**Gaskets:**

Quantity (per Carb)	Gasket Part Number	Usage Description		
1	G1-77	Air Inlet Module	To	Air Inlet Pipe
1	G1-76-1	Air Inlet Module	To	Gas Inlet Module
1	G1-78-1	Gas Inlet Module	To	Mixture Outlet Module
1	G1-38	T2-67, T2-17 Mixture Outlet Modules	To	Intake Manifold
	G1-29	T2-9 Mixture Outlet Module		
	S3-138	T2-80 Mixture Outlet Module		



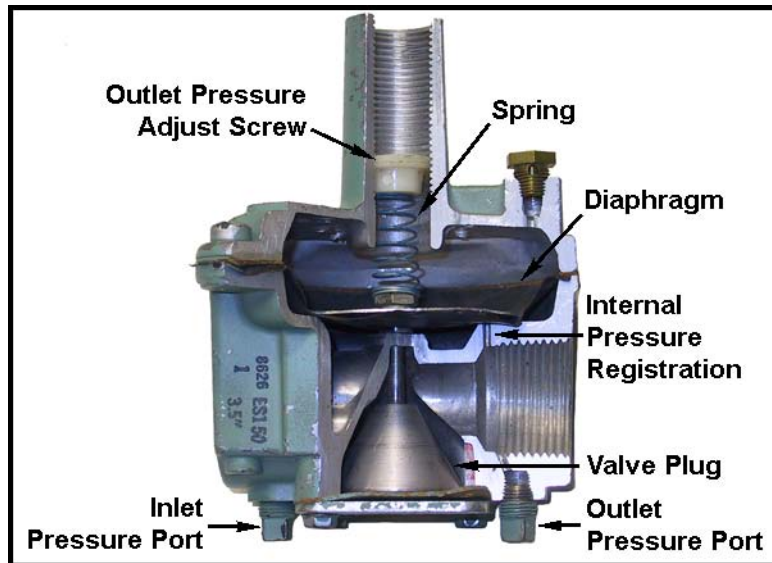
## 600VF3D:

### Hard parts:

Quantity (per Carb)	IMPCO Part Number	Description
2	RK-D1-20-3	Repair Kit, fluorosilicone diaphragm (blue). Includes plate, screws & upper anti-wear bushing.
2	B3-60	Lower guide bushing (brown)
2	V1-17	Air valve (anodized aluminum)
2	C1-32	Cover, diaphragm

### Gaskets:

Quantity (per Carb)	Gasket Part Number	Usage	Description			
1	G1-79	A2-17	Air Inlet Module	To	Air Inlet Pipe	
	G1-82	A2-18-2 A2-62				
	G1-86	A2-23				
1	G1-151 (Turbo)	A2-17 A2-18-2 A2-23 A2-62	Air Inlet Module	To	AT2-18-3 AT2-62-2	Mixture Outlet Module
	G1-81-1	A2-17 A2-18-2 A2-23 A2-62			AT2-18-1	
1	G1-80	T2-18 T2-18-3 T2-62-2	Mixture Outlet Module	To	Intake Manifold or Adapter Plate	
Optional	G1-79	A3-38	Adapter Plate	To	Intake Manifold	
	G1-86	A3-44				



**Figure #36**

# Pressure Regulators

## Introduction:

A pressure regulator maintains a desired, reduced outlet pressure while providing the required fluid or gaseous flow to satisfy a variable downstream demand. The value at which the reduced pressure is maintained is the outlet pressure setting of the regulator. In most pressure reducing regulators, increasing force of downstream pressure closes the regulator main valve.

Pressure regulators are simple control devices in which all of the energy needed for operation is derived from the controlled system, requiring no external power sources. Based on the axiom that the simpler a control system is, the better it is (as long as it does the job), the simplicity of regulators makes them a standard of the industry. Pressure regulators typically cost less to buy, install and maintain. Also, they are more compact and lighter than other control systems.

## Two Main Types of Regulators:

All regulators for pressure control are either *direct-operated* or *pilot-operated*.

### Direct-Operated Regulators (Single-Stage Regulators) Figure #36:

These types of regulators can handle applications in which an outlet pressure change of 10% to 20% of setpoint is acceptable.

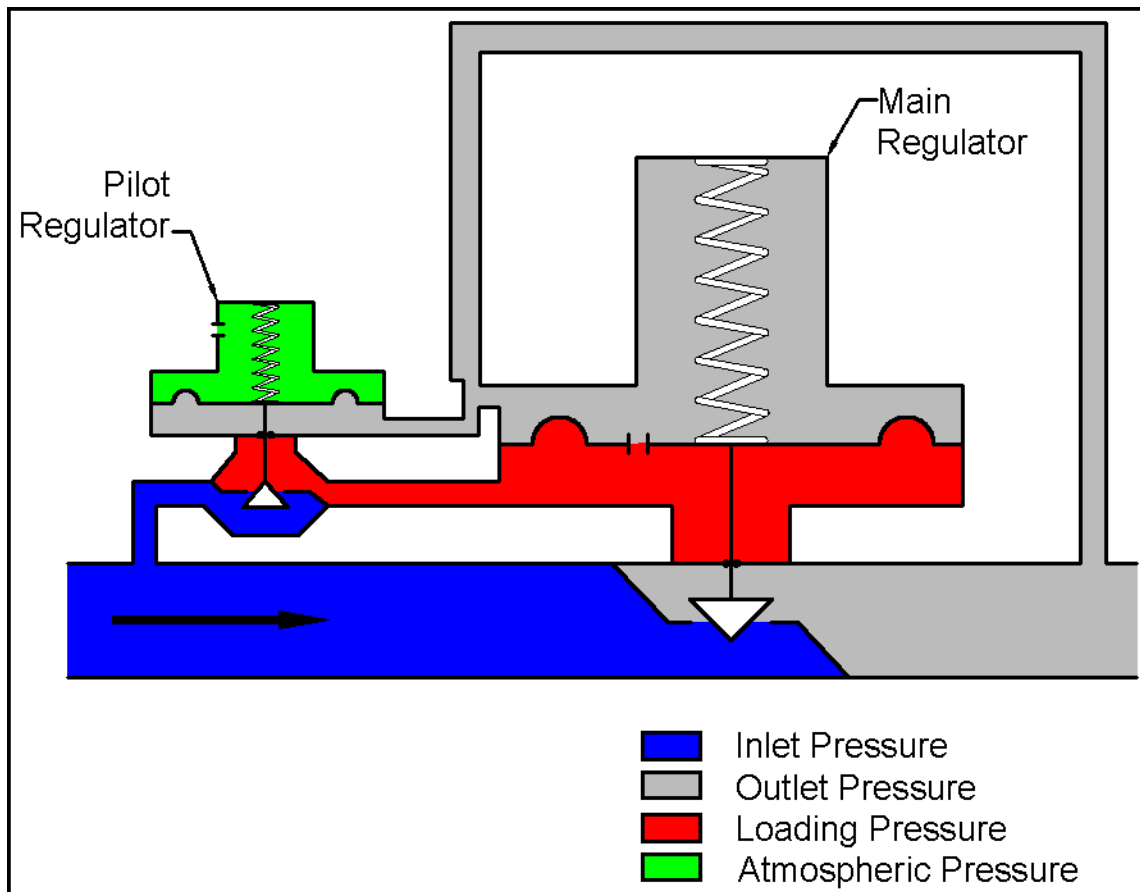
Typical applications include:

- Industrial, commercial, and gas service.
- Instrument air or gas supply.
- Fuel gas to burners.
- Water pressure control.
- Steam service.
- Tank blanketing.

The biggest advantages of direct-operated regulators include simplicity of design, construction and operation. But their output is non-linear because their spring loading system causes much of the droop<sup>(1)</sup> found in regulator operation. Therefore, to attain high flow rates without excessive droop, another form of loading must be used.

<sup>(1)</sup>Droop is defined as the decrease in controlled pressure that occurs when moving from a low-load to full-load flow condition. It is normally expressed as a percent and is often referred to as *proportional band*.

### Pilot-Operated Regulators (Two-Stage Regulators) Figure #37:



**Figure #37**

These types of regulators are a better choice when the allowable change in outlet pressure must be less than 10% of the outlet pressure setpoint. Applications are similar for those with direct-operated regulators, but where greater accuracy and/or higher flow is required. This type of regulator does the same job as one that is direct-operated. However, instead of relying upon spring force to open the main valve, an auxiliary device called the pilot supplies loading pressure against the regulator diaphragm to open the valve. The pilot (also called a relay, amplifier or multiplier) multiplies a small change in downstream pressure into a large change in the loading pressure applied to the regulator. It is this multiplying effect that enables pilot-operated regulators to control pressure with greater accuracy.

Almost all pilot-operated regulators have downstream control lines. These provide versatility in controlling pressure at a given location in the downstream system.

## Regulator Factors to Consider:

Regulator capacity information is based on very specific flow conditions, which means a flow rate typically is given for a specific setpoint, inlet pressure and droop. The flow rate will vary depending on regulator body size, orifice size and spring selection.

To correctly size a regulator, you need to consider:

- Maximum and minimum inlet pressure.
- Maximum expected flow rate.
- Flowing medium.
- Temperature.
- Acceptable accuracy or droop.

The minimum inlet pressure and maximum flow are very critical in regulator sizing. The regulator has to be large enough to pass the maximum flow required even with a low inlet pressure or a starved condition at the inlet.

In general, if more than one orifice can handle the flow, choose the smallest diameter orifice. This improves performance and minimizes shut-off problems.

If two or more springs have published pressure ranges that cover the desired pressure setting, use the spring with the lower range to gain better accuracy.

The regulator body size will not necessarily be the same size as the pipeline and should never be larger. Often, the regulator body is one size smaller than the pipe size. Best performance is obtained with the smallest body and orifice selection that will handle the flow.

Most soft seated regulators maintain the pressure within reasonable limits down to zero flow.

Every regulator represents a blend of such factors as:

- Price
- Capacity
- Accuracy
- Stability
- Simplicity
- Speed of response

## Comparison of Regulator Types:

Type	Accuracy	Capacity	Speed of Response	Cost
Direct-Operated			■	■
Pilot-Operated	■	■		

■ = Better



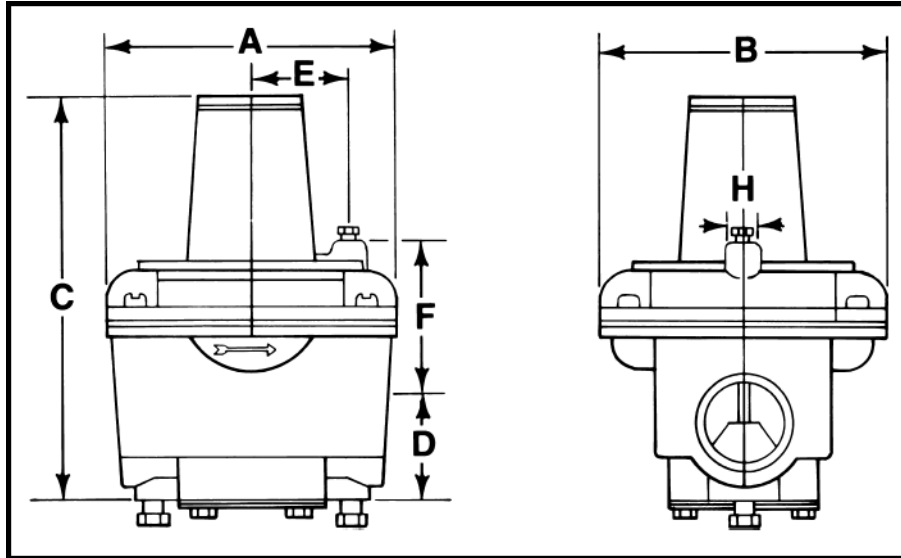
***IMPCO IMP Regulator***

# IMPCO IMP Regulators

## Fuel Pressure Regulators for VARIFUEL Carburetors

### Specifications:

### Dimensions (Standard Pressure Reduction Valves):



Standard Pressure Reduction Valve	A Overall Length	B Overall Width	C Overall Height	D Bottom to Center of Vapor Fuel Outlet	E Centerline to Center of Vent Boss	F Center of Vapor Fluid Outlet to Top of Vent Boss	G Inlet & Outlet NPT	H Vent Boss Diameter	Application
IMP52	3 3/16"	3 1/4"	5 1/16"	1 1/2"	1 3/32"	2"	3/4"	1/8"	CA55/100 Series
IMP53	3 5/8"	3 7/8"	5 9/16"	1 11/32"	1 15/32"	2 11/32"	1"	1/8"	200 Series
IMP60	4 3/8"	5 7/16"	6 7/16"	1 21/32"	1 27/32"	2 7/8"	1 1/4"	1/8"	400VF3 Series
IMP81	6"	7"	8 3/8"	2 1/32"	2 3/8"	3 1/16"	1 1/2"	1/8"	600VF3 Series
IMP91	7 1/8"	9 1/8"	10 1/2"	2 7/16"	3 1/4"	4 3/16"	2"	1/8"	600VF3 & 600VF3D Series

## **General Information:**

There are three main factors which affect the air/fuel ratio. They are:

- Size and shape of the gas valve.
- Power adjust screw on the carburetor.
- Fuel pressure entering the carburetor.

## **Gas Valve and Jet:**

The IMPCO VARIFUEL series carburetors are designed to accept various sizes and shapes of gas valves and jets to accommodate different fuel types and various engine performance curves. In addition, custom-built gas valves and jets are available for special applications. For more information, contact your nearest IMPCO distributor.

## **Power Adjust Screw:**

The power adjust screw on the carburetor determines the air/fuel mixture when the engine is at full power (rated speed under full load). It can be adjusted for best power, best fuel economy, or best emissions. The power adjust screw will have little effect when the engine is starting or idling. If it does, the power adjust screw is set too far in, and the engine will not be able to develop full power.

## **Fuel Pressure:**

The pressure of the fuel entering the carburetor will have a significant effect on the air/fuel ratio when the engine is starting, idling, or running under light loads. Under heavy loads, the fuel pressure will have little effect on the air/fuel ratio.

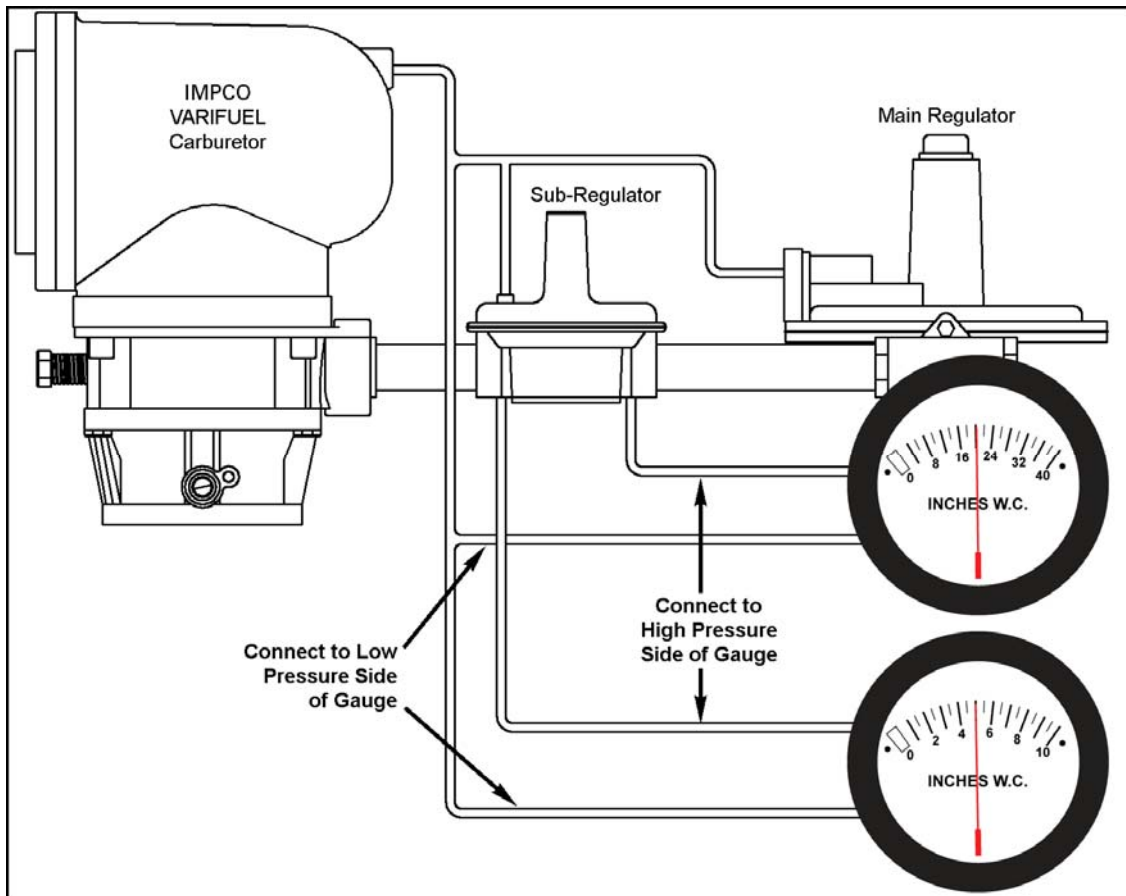


## Standard IMPCO VARIFUEL Carburetor Fuel Inlet Pressure:

The IMPCO VARIFUEL 400VF3, 600VF3 and 600VF3D carburetors are designed for a constant fuel inlet pressure of 5 inches water column (5" H<sub>2</sub>O column, measured with the engine at fast idle). In addition, the fuel inlet pressure should not drop by more than 1.5" H<sub>2</sub>O column as the engine approaches full power (rated speed under full load). If it does, refer to *VARIFUEL Carburetor Adjusting and Maintenance* on page 69 and verify the engine will achieve maximum power. If it will not, then there are too many restrictions in the fuel supply line network or the sub-regulator is too small.

For this reason, the fuel pressure sub-regulator should be located close to the carburetor, with no elbows to restrict the flow. The best approach is to use a main regulator and a sub-regulator in series. In this case, the main regulator produces around 20" H<sub>2</sub>O column of fuel pressure, and a sub-regulator (located within two feet of the carburetor) produces 5" H<sub>2</sub>O column of fuel pressure to the carburetor (see figure #38).

NOTE: The input pressure to the sub-regulator (IMP) must not exceed 1 PSI (27" H<sub>2</sub>O column) of fuel pressure.



**Figure #38**

## Flow Capacities:

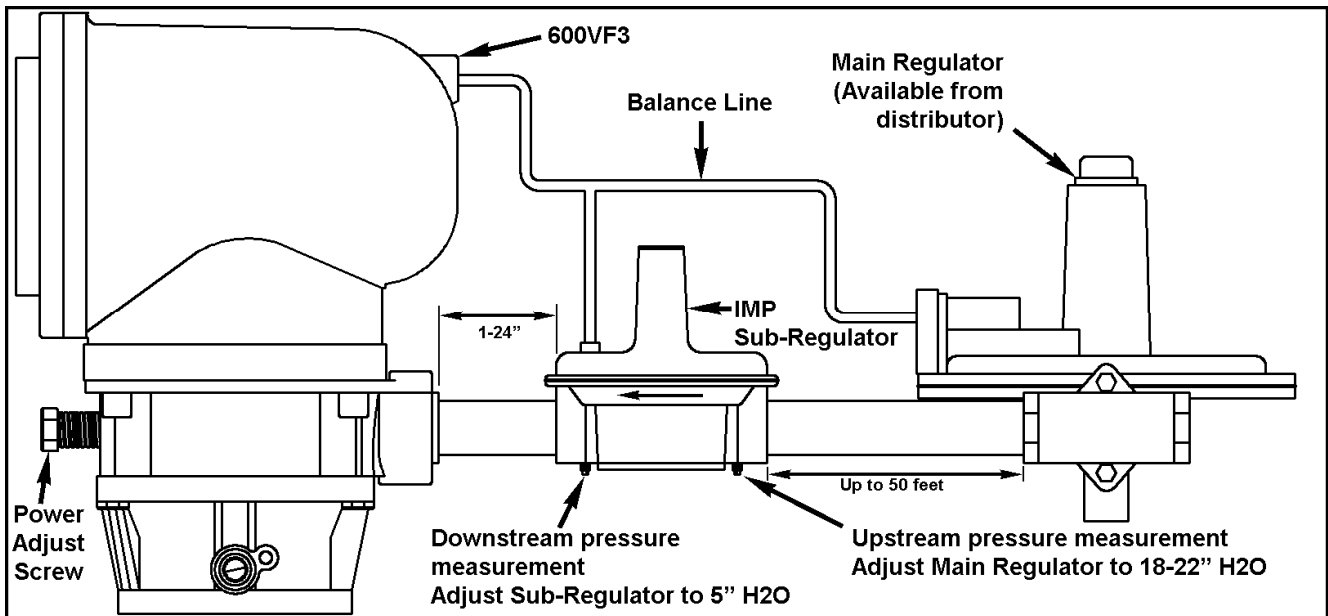
The following chart illustrates pressure drop values for each model IMP regulator in the full open position. Differential pressure (inlet pressure minus outlet pressure) must be at least twice the pressure drop value for practical use. Maximum recommended capacity limit is at a flow equivalent to 4.0 inches H<sub>2</sub>O pressure drop.

Rate of Flow (CFH/0.64 Specific Gravity of Gas)	Pressure Drop (Inches Water Column)				
10,000					
9,500					
9,000					
8,500					4.95
8,000					4.39
7,500					3.85
7,000					3.35
6,500					2.90
6,000					2.46
5,500				5.90	2.07
5,000				4.86	1.71
4,500				3.95	1.39
4,000				3.12	1.09
3,500			7.90	2.38	0.84
3,000			5.80	1.76	0.62
2,500			4.03	1.22	0.43
2,000			2.58	0.78	0.27
1,900			2.33	0.71	0.25
1,800		4.80	2.09	0.63	0.22
1,700		4.27	1.87	0.56	0.20
1,600		3.78	1.65	0.50	0.18
1,500		3.31	1.45	0.44	0.15
1,400		2.90	1.26	0.38	0.14
1,300		2.52	1.09	0.33	0.12
1,200		2.13	0.93	0.28	
1,100	5.30	1.79	0.78	0.24	
1,000	4.37	1.48	0.64	0.20	
900	3.55	1.20	0.52	0.16	
800	2.82	0.95	0.41	0.13	
700	2.16	0.73	0.32		
600	1.58	0.54	0.23		
500	1.10	0.37	0.16		
400	0.70	0.24			
300	0.39	0.13			
200	0.18				
100					
IMP Model	52	53	60	81	91
Pipe Size	3/4"	1"	1 1/4"	1 1/2"	2"

## Regulator Installation

### Primary Regulator & Sub-Regulator:

The regulator should be located in the fuel line (as close to the carburetor as possible) to reduce restrictions and prevent surging in the fuel system. If the primary regulator will be more than twelve feet away from the carburetor, an IMP sub-regulator is required, downstream from the primary regulator (see figure #39). In this configuration, the primary regulator can be any distance from the carburetor, but the IMP sub-regulator should be within two feet of the carburetor. Even when the primary regulator is close to the carburetor, the IMP sub-regulator is recommended for more precise control of the fuel pressure, which allows better control of the exhaust emissions and fuel economy.



**Figure #39**

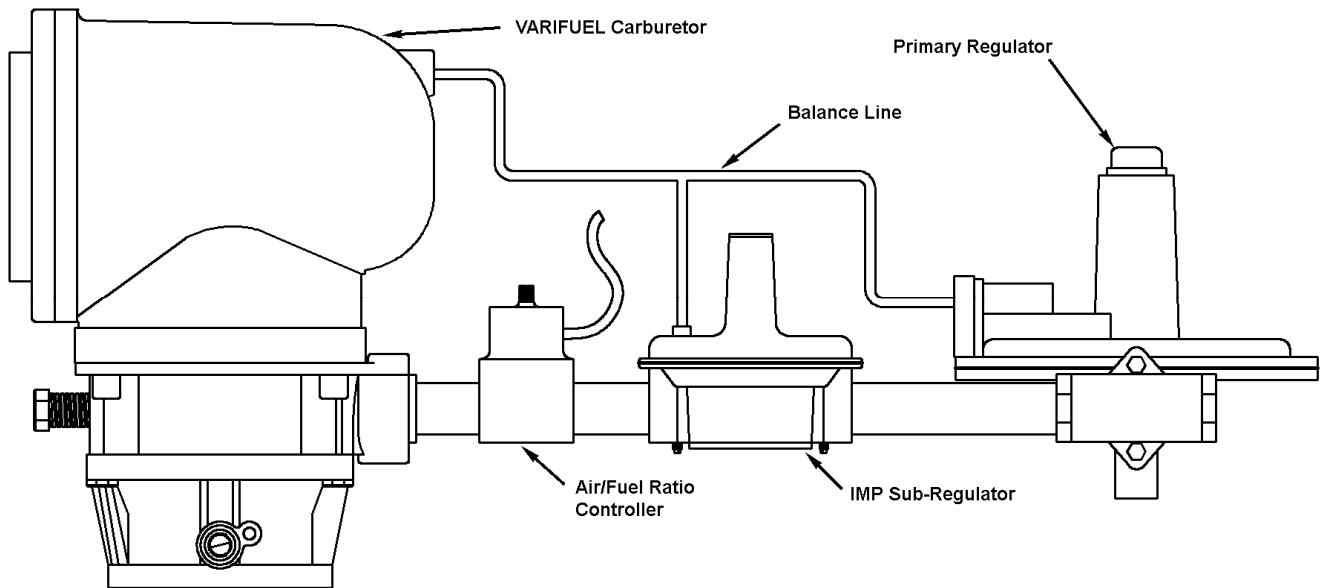
The IMP sub-regulator must be mounted upright (as in figure #39). Also, the arrow on the IMP sub-regulator represents the direction of fuel flow. **DO NOT connect the regulators backwards. Never apply more than 1 PSI (27" H<sub>2</sub>O) to the IMP sub-regulator.**

### Balance Lines:

In all configurations, you should install a balance line between the primary regulator, sub-regulator (if used) and the carburetor inlet (see figure #39). This is especially important on turbocharged engines. Without the balance line, a turbocharged engine will be starved for fuel under any significant load. Use 5/16" or (preferably) 3/8" pipe or steel tubing for the 400VF3 and 600VF3 carburetors and 3/8" or (preferably) 1/2" ID pipe or steel tubing for the 600VF3D duplex carburetor. The use of copper tubing is not recommended. On some primary regulators, you will need to remove the vent screen, and install a 1" NPT reducer in its place.

### Air/Fuel Ratio Controller:

If you use a separate air/fuel ratio controller, install it **between** the sub-regulator and the carburetor (see figure #40).



**Figure #40**

### Fuel Lines:

For fuel line connections, use local code approved pipe. Use a liquid thread sealant (such as Loctite 567 or equivalent) on all pipe threads. **DO NOT** use Teflon tape, because it can foul the carburetor.

## Adjusting Primary and Sub-Regulators

Before you can start the engine, you will need to preset the power adjust screw. This should prevent misfire and detonation while you are setting the fuel pressure. The power adjust screw (see figure #39) determines the air/fuel ratio while the engine is under load. A good starting point for this screw is four turns out from base (screw spring fully compressed) for the 400VF3 and 600VF3 carburetors and three turns from base for the 600VF3D duplex carburetor.

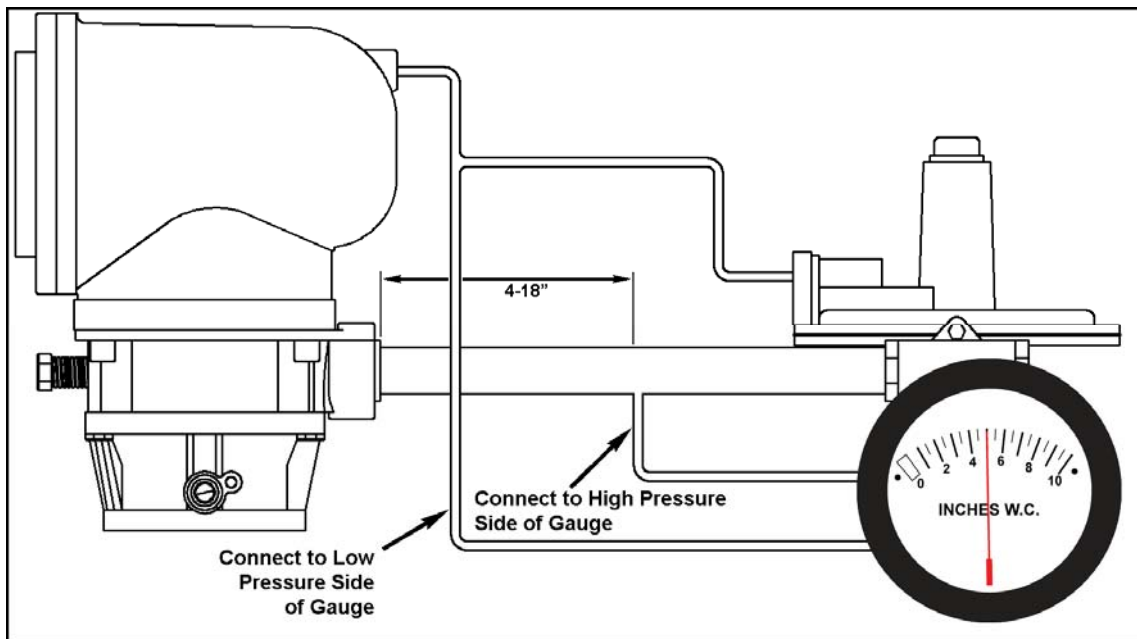
NOTE: If detonation occurs, **lean** the mixture (tighten the power adjust screw) slightly before you proceed. If you cannot take the engine from idle to full load without detonation, you will need a custom gas valve.

### Primary Regulator Only:

If you will be using a primary regulator without a sub-regulator, you will need to install the manufacturer's recommended spring to maintain 5" H<sub>2</sub>O outlet pressure.

### Adjusting the Primary Regulator:

- 1) Connect the high pressure side of a manometer or sensitive pressure gauge (such as the IMPCO TG-010- include in ITK-1 tool kit) to the fuel line 4-18" from the carburetor. Connect the low pressure side of the meter/gauge to the balance line (see figure #41).



**Figure #41**

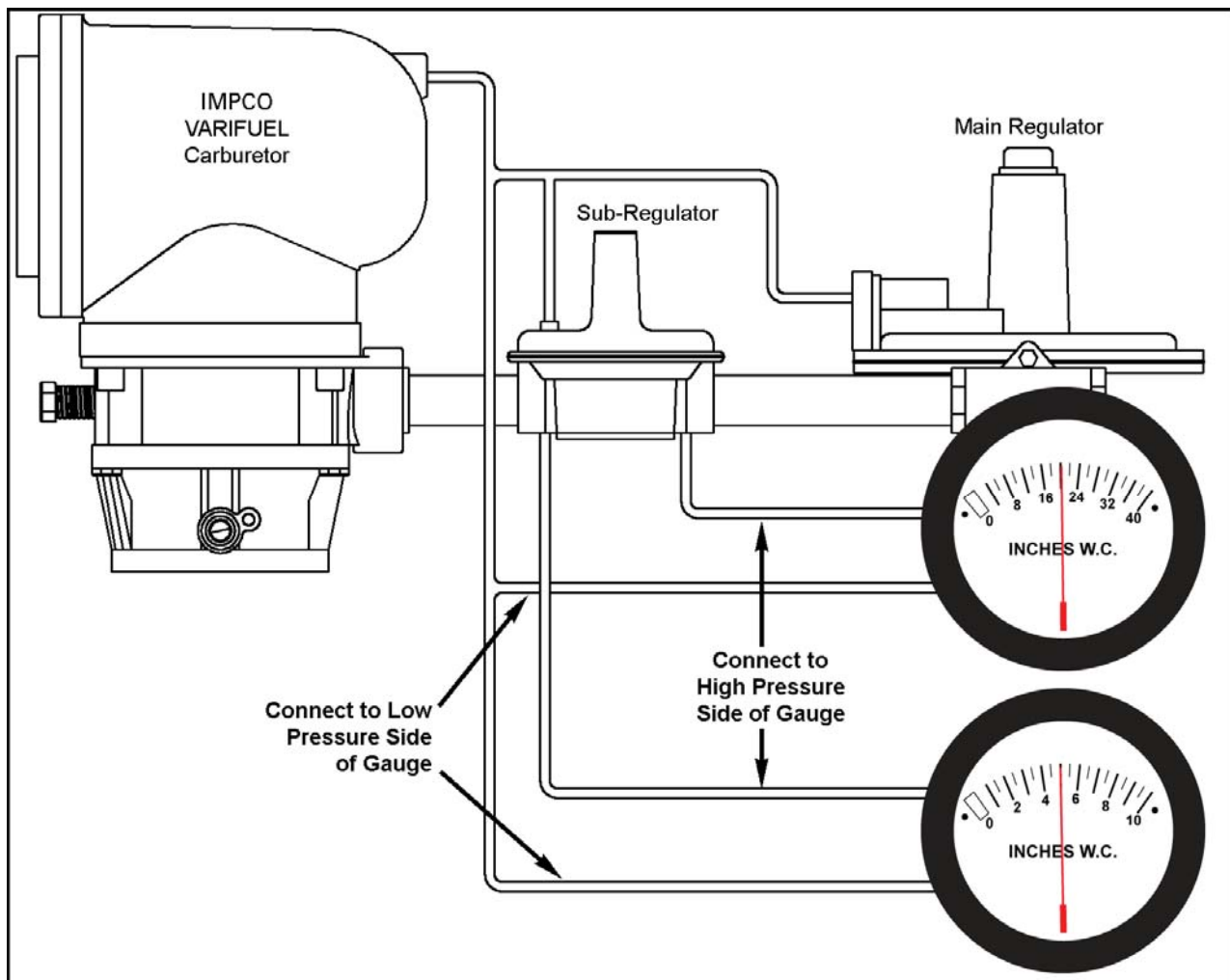
- 2) Turn on the fuel supply.
- 3) Start the engine, and run it at fast idle (rated speed, no load). Following the manufacturer's instructions, adjust the regulator until the meter/gauge reads 5" H<sub>2</sub>O column.

## Primary Regulator with IMP Sub-Regulator:

If you are using both a primary regulator and an IMP sub-regulator, adjust the primary regulator first. You will need to install the primary regulator manufacturer's recommended spring to maintain 20" H<sub>2</sub>O outlet pressure.

### Adjusting the Primary Regulator:

- 1) Connect the high pressure side of a manometer or sensitive pressure gauge (such as the Dwyer Magnehelic™ number 2-5040) to the IMP sub-regulator input pressure port. Connect the low pressure side of the meter/gauge to the balance line (see figure #42).
- 2) Connect the high pressure side of a manometer or sensitive pressure gauge (such as the IMPCO TG-010—include in ITK-1 tool kit) to the IMP sub-regulator output pressure port. Connect the low pressure side of the meter/gauge to the balance line (see figure #42).



**Figure #42**

- 3) Unscrew the dust cap on the primary regulator and turn on the fuel supply.

- 4) Start the engine, and run it at fast idle (rated speed, no load). Turn the pressure adjusting screw on the primary regulator until the appropriate meter/gauge reads 18-22" H<sub>2</sub>O column. Reinstall the dust cap on the primary regulator.

### **Adjusting the IMP Sub-Regulator:**

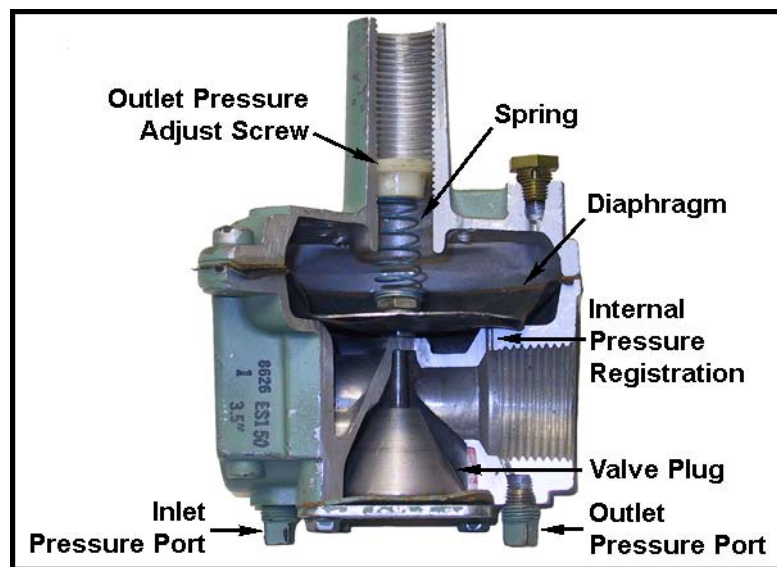
After the primary regulator is properly adjusted, you can proceed to adjusting the IMP sub-regulator.

- 1) Unscrew the dust cap on the IMP sub-regulator and maintain the engine at high idle.
- 2) Turn the IMP sub-regulator pressure adjusting screw until the appropriate meter/gauge reads 5" H<sub>2</sub>O column.

### **Replacing the IMP Sub-Regulator Spring:**

If you cannot adjust the IMP sub-regulator to 5" H<sub>2</sub>O column, then you will have to install a different spring.

- 1) Turn off the fuel supply and slowly release the pressure in the fuel line.
- 2) Unscrew the dust cap on top of the IMP sub-regulator. Remove the pressure adjusting screw from the neck of the regulator by unscrewing it. Remove the spring and install the alternate spring (see figure #43).



**Figure #43**

- 3) Reinstall the pressure adjusting screw and tighten it to about half way down the neck of the regulator.
- 4) Turn on the fuel supply and perform the 2-step IMP sub-regulator adjustment (see above).

## General Information

### A. Gaseous Fuel Types:

Fuel Type	Origin	BTU per ft <sub>3</sub>	Common Usage	Engine Applications
Natural Gas (NG, CNG, LNG)	<ul style="list-style-type: none"> <li>Gas Wells</li> </ul>	750–1,150	<ul style="list-style-type: none"> <li>Engine Fuel</li> <li>Co-generation</li> <li>Cooking</li> <li>Heating</li> <li>Water Heating</li> <li>Air Conditioning</li> <li>Clothes Dryers</li> </ul>	<ul style="list-style-type: none"> <li>Automotive</li> <li>Off-Road and Farm Vehicles</li> <li>Material Handling</li> <li>Industrial Engines</li> </ul>
LPG	<ul style="list-style-type: none"> <li>Light Crude Oil</li> <li>Gasoline Extraction</li> <li>Natural Gas</li> </ul>	2,500	<ul style="list-style-type: none"> <li>Engine Fuel</li> <li>Co-generation</li> <li>Cooking</li> <li>Heating</li> <li>Water Heating</li> <li>Air Conditioning</li> <li>Clothes Dryers</li> </ul>	<ul style="list-style-type: none"> <li>Automotive</li> <li>Off-Road and Farm Vehicles</li> <li>Material Handling</li> <li>Industrial Engines</li> </ul>
Butane Gas	<ul style="list-style-type: none"> <li>Light Crude Oil</li> <li>Gasoline Extraction</li> <li>Natural Gas</li> </ul>	2,700	<ul style="list-style-type: none"> <li>Engine Fuel</li> <li>Co-generation</li> <li>Cooking</li> <li>Heating</li> <li>Water Heating</li> <li>Air Conditioning</li> <li>Clothes Dryers</li> </ul>	<ul style="list-style-type: none"> <li>Automotive</li> <li>Off-Road and Farm Vehicles</li> <li>Material Handling</li> <li>Industrial Engines</li> </ul>
Biogas (Landfill & Digester)	<ul style="list-style-type: none"> <li>Sewage and Waste Treatment Facilities</li> </ul>	400- 750	<ul style="list-style-type: none"> <li>Stationary Engine Fuel</li> <li>Co-generation</li> </ul>	<ul style="list-style-type: none"> <li>Industrial Engines</li> </ul>
Coal Seam Gas	<ul style="list-style-type: none"> <li>Coal Fields</li> </ul>	500-750	<ul style="list-style-type: none"> <li>Stationary Engine Fuel</li> <li>Co-generation</li> </ul>	<ul style="list-style-type: none"> <li>Industrial Engines</li> </ul>

### B. Gaseous Fuel Benefits:

- 1) Reduced emissions
- 2) Longer engine life
- 3) Reduced maintenance cost
- 4) Eliminates fuel pilferage, spillage and evaporation
- 5) Improved fuel system integrity
- 6) Eliminates underground fuel storage concerns



### C. Pressure Conversion Chart:

LPG and CNG are stored under high pressure. These high pressures must be reduced before the fuel enters the engine. Therefore, it is very important to be familiar with the different types of pressure measurements used to test and troubleshoot problems with gaseous fuel systems. The following chart reflects how the different pressure units relate to each other.

Chart Instructions:

- 1) Find the known unit of pressure in the rows on the left.
- 2) Find the unit of pressure you want to convert into in the columns on the top.
- 3) Multiply by the factor in the corresponding square.

Example:

To convert 23.6 Inches of Water Column to Millibars, multiply the 23.6 by 2.491:  
 $23.6 \times 2.491 = 58.8$  Millibars

	Inches of Water Column	Inches of Mercury Column	Pounds per Square Inch (PSI)	Kilopascal (kPa)	Millibar
Inches of Water Column	1	0.074	0.036	0.249	2.491
Inches of Mercury Column	13.7	1	0.491	3.386	33.864
Pounds per Square Inch (PSI)	27.68	2.036	1	6.895	68-948
Kilopascal (kPa)	4.015	0.295	0.145	1	10.0
Millibar	0.401	0.030	0.015	0.100	1

### D. Crankcase Oil Requirements:

Always follow the engine manufacturer's recommendations for oil type and change intervals. Oil used in gaseous-fueled engines may remain cleaner than oil in gasoline or diesel engines. However, the affects of friction, heat and pressure cause oil to deteriorate and it should be changed even though it looks clean.

## E. Effects of Air Temperature on Power Output:

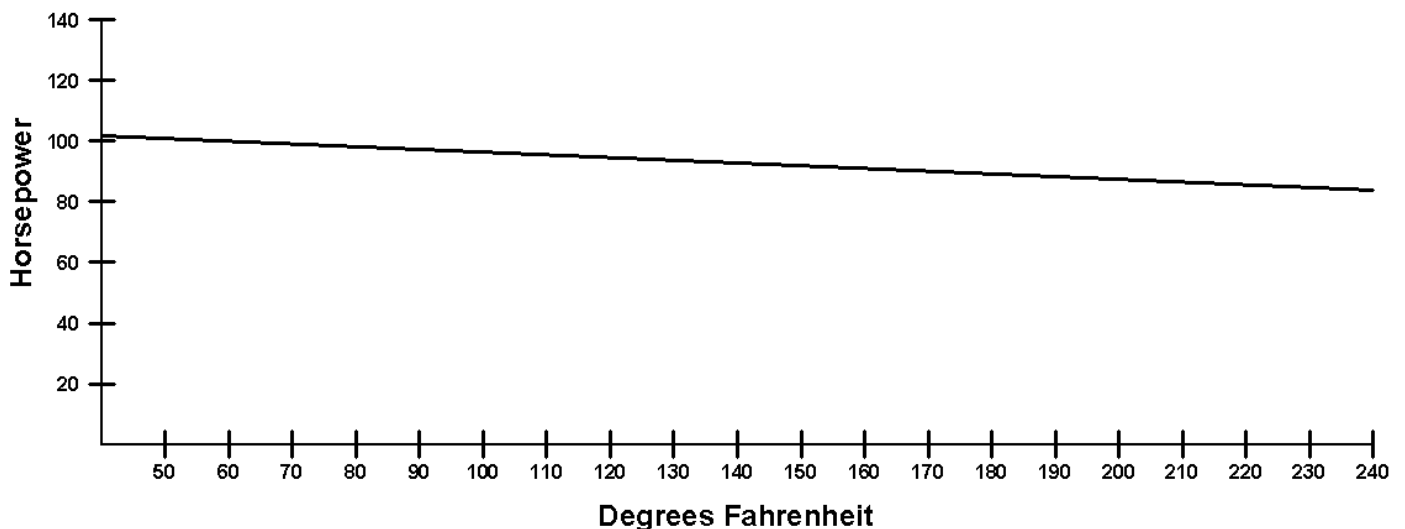
The temperature of the air entering an engine is very important for two reasons:

- 1) Hot air entering an engine can cause detonation and pre-ignition, which will damage or destroy an engine in short order. The cooler the temperature of the engine's incoming air, the better it is for the engine.
- 2) As air temperature rises, its density is reduced through expansion. This reduction in density decreases the volumetric efficiency of the engine with a resultant decrease in power output. The power output of an engine is calculated at 59°F (15°C) and a pressure of one atmosphere (14.7 PSI- sea level). For every ten-degree Fahrenheit (10°F, 5.6°C) increase in temperature, there is a one percent (1%) loss in the engine's power output. This decrease in power output can be explained by the fact that **an engine requires seven pounds of air to make one horsepower (HP) for one hour**. As the air is heated, it expands becoming lighter (like a hot air balloon). Since the air is now lighter, it takes a larger volume to make up the seven pounds required to make the one HP. An engine running at its rated full load rpm can only pump a fixed volume of air. A 100 CID 4-stroke engine can only push 100 cubic inches of air for every 2 revolutions of the crankshaft. The displacement is fixed by the engine's bore and stroke.

Example:

An engine produces 100 HP breathing in air at 60°F. This same engine will only make 82 HP breathing in air at 240°F.

$$\text{HP} = 100 - \left[ 100 \left( (240 - 60) \div 10 \right) (0.01) \right] = 100 - 18 = 82$$



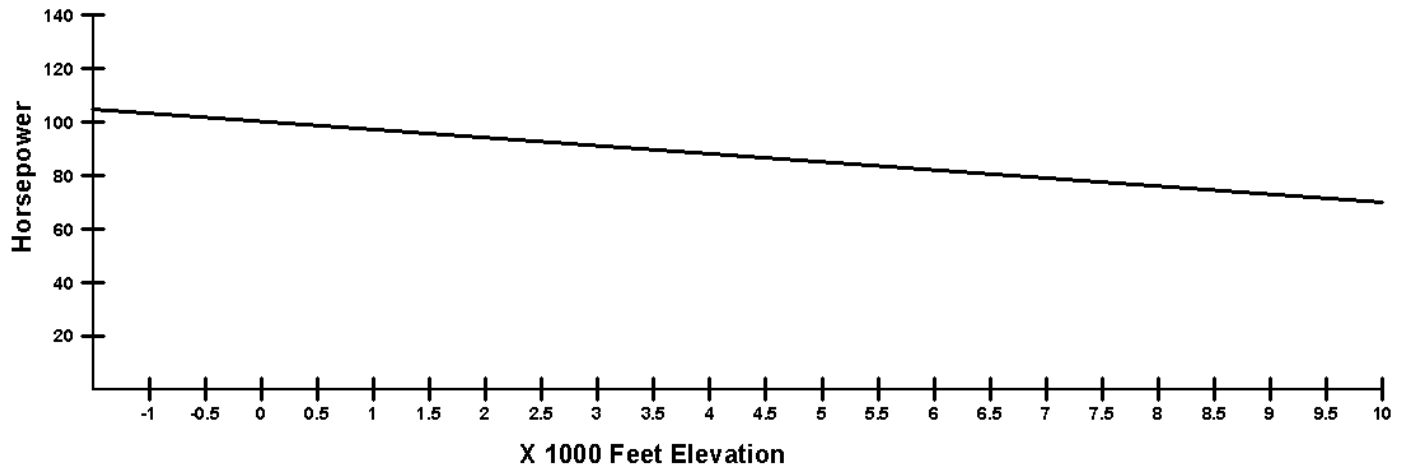
## F. Effects of Altitude on Power Output:

The altitude at which an engine is operating has a dramatic effect on its power output. As stated earlier, an engine's power output is calculated at 59°F (15°C) and a pressure of one atmosphere (14.7 PSI- sea level). As altitude increases, the density of the air decreases due to less available atmosphere molecules (at sea level there is 14.7 pounds of air molecules pushing down on every square inch, decreasing with altitude). This has the same effect on power output as increasing temperature. The rate of power output decrease is 3% for every 1,000 foot increase in altitude.

Example:

An engine that produces 100 HP at sea level will only produce 70 HP at 10,000 feet.

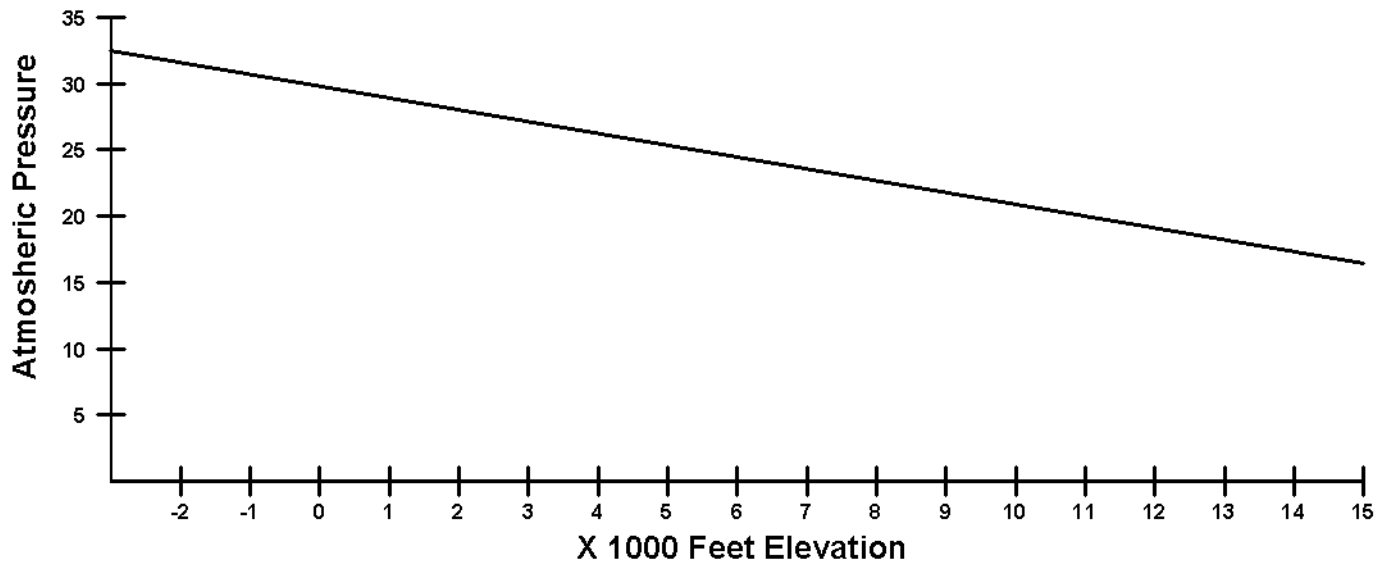
$$\text{HP} = 100 - \left[ 100 \left( 10000 \div 1000 \right) \left( 0.03 \right) \right] = 100 - 30 = 70$$



### G. Effects of Altitude on Intake Manifold Depression (Vacuum):

- 1) The Absolute Pressure produced in the intake manifold during the intake cycles of an engine is constant at approximately nine inches (9") of mercury (HG) column above zero absolute pressure (with engine unloaded).
- 2) Manifold depression (as measured with a mercury manometer) is the difference between 9" absolute pressure and atmospheric pressure.
  - At sea level, 29.92" HG column atmospheric pressure minus 9" HG column manifold pressure will read 20.92" manifold depression on the HG manometer.
- 3) Manifold depression lessens at higher altitudes due to the lower density of the air at increasing altitudes.
  - Atmospheric pressure at 15,000' altitude is approximately 16.45" of HG column. The manifold depression at 15,000' is:  $16.45" - 9" = 7.45"$  HG column.

NOTE: Refer to *Correction Table for Altitude* on page 133 for the standard manifold depression corrections at selected altitudes.



## H. Air Displacement by Fuel (and the Effect On Power Output):

- 1) Diesel direct injection displaces no air due to the fuel being injected after all of the air is drawn into the engine during the intake cycle.
- 2) Gasoline vapor displaces a minimal amount of air at full load since it is only partially vaporized as it enters the cylinder. Also, vaporization of gasoline cools the incoming air making it denser adding mass to the intake charge.
- 3) Propane enters the induction system as a vapor adding no cooling effect to the charge from vaporization.

- Propane's stoichiometric (ideal) fuel ratio is 15.6 parts air to 1 part fuel (15.6/1) by weight. This is the ratio of air and fuel where all of the fuel and most of the oxygen ( $O_2$ ) is consumed in combustion resulting in the best performance with least emissions.
- Propane weighs 0.1187 pounds (#) per cubic foot ( $ft^3$ ).
- Air weighs 0.076# per  $ft^3$  (at sea level).
- Propane's stoichiometric ratio by volume would then be:

$15.6 \text{ (parts air)} \times 0.1187 \text{ (# of propane)} = 1.85\# \text{ of air.}$

$1.85 \text{ (# air)} \div 0.076 \text{ (# air/ft}^3\text{)} = 24.34 \text{ (ft}^3 \text{ of air)} = 24.34 \text{ parts air/1 part propane by volume.}$

Assuming negligible displacement of air by gasoline, an engine running on gasoline and consuming 92,000  $ft^3$  of air per hour would produce 999 HP. The HP produced running the same engine on propane (due to the air displacement) would be:

$24.3 \text{ (ft}^3 \text{ air)} + 1 \text{ (ft}^3 \text{ propane)} = 24.34 \text{ ft}^3 \text{ total volume.}$

$92,000 \text{ (ft}^3 \text{ air)} \div 24.34 \text{ (ft}^3 \text{ total)} = 3780 \text{ ft}^3 \text{ propane}$

$92,000 \text{ (ft}^3 \text{ air)} - 3780 \text{ (ft}^3 \text{ propane)} = 88,220 \text{ ft}^3 \text{ air}$

- Remembering an engine requires 7# of air to make 1 HP for one hour:
  - $88,220 \div 92.1 \text{ ft}^3 \text{ [volume of 7# of air (7} \div 0.076)] = 957.9 \text{ HP}$
- 4) Natural Gas (NG) has an even higher displacement of air resulting in even more loss of power output.
- NG stoichiometric ratio is 17.3/1 by weight.
  - NG weighs 0.052#/ft<sup>3</sup>
  - Using the same formulas, the power output for the same engine would be 921.1 HP running on NG.
  - Summary:

In this example, gasoline produces 999 HP

Propane produces 958 HP (4% air displacement)

NG produces 921 HP (8% air displacement)

## Air-Terms and Measurement

The condition of air is described by the terms:

- Atmospheric Pressure
- Absolute Pressure
- Pressure Differential
- Volume
- Weight and Density
- Gauge Pressure

### Atmospheric Pressure:

This is the absolute pressure above a perfect vacuum at any geographic location or temperature.

- The atmospheric pressure at seal level is calculated to be 29.92" of mercury column (14.7 PSI) at 59° Fahrenheit.
- Any change in altitude, temperature or movement of atmospheric air masses will change this figure, and will be shown on a barometer (which registers in inches of mercury column).

### Absolute Pressure:

This is the actual pressure above a perfect vacuum (which is impractical to produce mechanically).

### Pressure Differential:

This is the difference between two pressures, generally with reference to atmospheric pressure as one of the two.

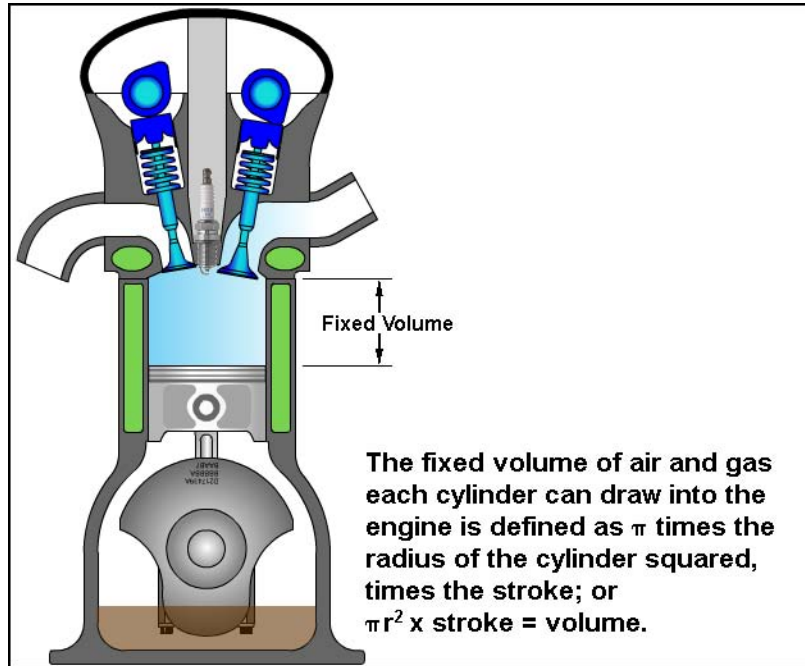
- Intake manifold depression (vacuum) is actually a measurement (in inches of mercury) between atmospheric pressure and absolute pressure within the manifold as produced by the air pumping action of the engine against the throttle valve. When the throttle valve is nearly closed (idle or deceleration), then intake manifold depression is high. When the throttle valve is wide open (hard acceleration), then intake manifold depression is low.
- Average absolute pressure obtainable inside the intake manifold of an unloaded engine is 9" of mercury, or about 4.5 PSI above a perfect vacuum. Since the mean atmospheric pressure at sea level is 29.92" Hg (mercury), it follows:

29.92" Hg (atmospheric absolute) minus 9" Hg = 20.92" Hg manifold depression (vacuum). This is what you read on an intake manifold vacuum gauge.

## Volume:

Volume is constant, being a measurement of space rather than a condition of air or gas.

- Since an engine of given displacement pumps air into cylinders of a constant size, the volume of air and gas required to fill those cylinders is constant.



When the carburetor throttle valve is closed (causing a high manifold depression or vacuum), the pistons continue to draw the same volume of air and gas into the cylinders. The only difference between this condition and when the engine is at wide open throttle is the weight and density of the charge are less. A supercharged engine also draws the same volume into the engine, with the weight and density of the charge being greater than a normally aspirated engine. In the IMPCO air valve carburetor, the air valve opens in relation to throttle position the same distance, whether the engine is naturally aspirated or supercharged to several pounds above atmospheric pressure.

- The only change in total volume entering the cylinders occurs when rpm changes. The same volume is drawn in per revolution; however, there are more or less revolutions in the allotted time.

## Weight and Density of Air:

- Weight and density of air of a given volume vary proportionally with pressure. An air receiver tank filled with air at atmospheric pressure will float on water. The same tank of air pressurized to 1000 PSI contains a more dense mass of air, and the increased weight will cause it to sink.
- During the compression cycle of an engine, while total weight of the charge drawn into a cylinder does not increase, the charge becomes denser as the piston compresses it. Consequently, the charge becomes heavier per cubic inch of volume when compressed.
- Weight and density of the charge introduced into the cylinder during the intake cycle directly affects the density of the charge upon compression. The denser the mass is (within practical limits), the more power will be produced when the charge is ignited.
- A higher compression ratio may be used at high altitude. Since the air/fuel mass drawn into the cylinder weighs less, it can be compressed to a higher degree to reach practical limits of density when ignited.

## Gauge Pressure:

This can be absolute pressure (as indicated on a barometer) or, more generally, a measurement above or below atmospheric pressure (as indicated on the vacuum gauge connected to the intake manifold).

## Air Properties:

- Weighs 0.076 lb/ft<sup>3</sup> @ 59° F and 29.92" Hg pressure.
- Weighs 3% less with each 1000 feet above sea level.
- Weighs approximately 0.042 lb/ft<sup>3</sup> @ 15,000 feet altitude.
- Weighs 1% less for each 10° above 59° F.
- Weighs approximately 0.0714 lb/ft<sup>3</sup> @ 120° F.
- 1 ft<sup>3</sup> of air contains 0.21 ft<sup>3</sup> oxygen @ 59° F and 29.92" Hg pressure.

## Natural Gas Properties (Average):

The average weight of natural gas (compared to air) is a product of the specific gravity of natural gas (0.695) times the weight of air (at a given temperature and pressure). The specific gravity of air is 1.0.

- By this formula, the average weight of natural gas is:  $0.695 \times 0.076 \text{ lb/ft}^3 = 0.0528 \text{ lb/ft}^3$  @ 59° F and 29.92" Hg pressure.
- The .0695 (specific gravity) times the weight of air is constant with altitude change (assuming air and gas temperature remain constant). Therefore, the air/fuel ratio remains constant from sea level to high altitude.



The BTU (British Thermal Unit) content of natural gas varies considerably from region-to-region and from producing field-to-producing field (within a region). Some regional natural gas BTU contents are:

- Texas (some fields)-High heat value of 742 BTU's/ft<sup>3</sup>.
- Pennsylvania-High heat value of 1228 BTU's/ft<sup>3</sup>.
- Oklahoma-High heat value of 1023 BTU's/ft<sup>3</sup>.
- Wisconsin-High heat value of 987 BTU's/ft<sup>3</sup>.
- High heat value (HHV) is the total amount of heat available in BTU's/ft<sup>3</sup> as measured by a calorimeter. It represents all of the potential heat in a cubic foot of gas.
- Low heat value (LHV) is the actual heat in BTU's/ft<sup>3</sup> available to do work. The difference is the BTU's/ft<sup>3</sup> used in the chemical reactions necessary to convert the air and gas into its combustion components (such as water and carbon dioxide). The low heat value is the high heat value times 0.902 (LHV = HHV x 0.902).

### **Propane Properties (Vapor):**

The weight of propane vapor (compared to air) is a product of the specific gravity of propane (1.5617) times the weight of air (at a given temperature and pressure). (The specific gravity of air is 1.0).

- By this formula, the weight of propane vapor is:  $1.5617 \times 0.076 \text{ lb/ft}^3 = 0.1187 \text{ lb/ft}^3$  @ 59° F and 29.92" Hg pressure.
- As with natural gas, the 1.5617 (specific gravity) times the weight of air is constant with altitude change (assuming air and gas temperature remain constant). Therefore, the air/fuel ratio remains constant from sea level to high altitude.

### **Horsepower (as it relates to BTU Consumption):**

Horsepower can be defined as: 2545 BTU's to make one horsepower for one hour (1 HP/Hr = 2545 BTU). However, most of the available BTU's in the fuel are wasted as heat exiting the exhaust. For an engine to produce one horsepower for one hour, it consumes approximately 10,000 BTU's. This is a very useful tool for determining regulator and fuel delivery pipe sizing.

## IMPCO VARIFUEL Carburetor Application by Engine Manufacturer

ENGINE MANUFACTURER	ENGINE MODEL	IMPCO VARIFUEL CARBURETOR
Caterpillar	G379	400VF3U-1-2
	G397	400VF3X-1-2
	G398	400VF3X-3-2
	G398 TA	NG400VF3X-3-2
	G399 TA	NG600VF3X-8-2 w/A2-27
	G3406	400VF3, 600VF3
	G3408	
	G3412	
	G3508	600VF3
	G3512	
	G3516	NG600VF3DX-6-2, 600VF3
	G3520	600VF3
Cooper- Superior	6G-825	600VF3DX-1, 600VF3DX-1-2, DG600VF3DX-1-2
	6GT-825	600VF3DX-1
	8G-825	600VF3DX-1, 600VF3DX-1-2, NG600VF3D-9-2
	8GT-825	600VF3DX-1
Cummins	L10-230	400VF3X-1-2
	L10-240NG	400VF3X-3-2
Cummins (Natural Gas)	G12/G-743	400VF3X-1-2
	GTA12/GTA-743A	400VF3X-3-2
	GTA14	600VF3
	GTA855A	
	GTA855B	
	GTA19/GTA-1150	
	GTA28/GTA-1710	600VF3 w/T2-7, 600VF3-125

ENGINE MANUFACTURER	ENGINE MODEL	IMPCO VARIFUEL CARBURETOR
Ingersoll-Rand	PVG-6	600VF3DX-3-2
	SVG-8	600VF3DX-3-2
	SVG-10	600VF3DX-5-2
	SVG-12	
	KVG-10	
	KVG-12	
	KVS-6	600VF3DX-3-2
	KVS-12	
	48KVG	
	410KVGB	
	412KVGR	
	412KVS	
Waukesha	12V-AT25GL	600VF3
	12V-AT27GL	
	8L-AT27GL	400VF3
	F1197G	400VF3U-1-2
	F817G	400VF3
	VFG F18G	
	VFG F18GL	
	VFG F18GLD	400VF3U-3-2
	VFG H24G	400VF3
	VFG H24GL	
	VFG H24GLD	
	VFG L36GL	600VF3
	VFG L36GLD	
	VFG P48GL	
	VFG P48GLD	
	VHP 2895	400VF3
	VHP 3521	600VF3

ENGINE MANUFACTURER	ENGINE MODEL	IMPCO VARIFUEL CARBURETOR
Waukesha	F3521GSI	600VF3U
	VHP 5108	600VF3U (2X)
	VHP 5790	
	L5790GSI	
	5790GL	
	VHP 7042	600VF3DU (2X)
	VHP 9390	600VF3DX (2X)
	P9390GSI	600VF3DX (4X)
	VSG F11G	400VF3U-1-2
	VSG F11GSI/GSID	400VF3U-3-2

## Large Engine Application Information Worksheet (Complete and forward to your local distributor)

Name: \_\_\_\_\_ Date: \_\_\_\_\_  
Company: \_\_\_\_\_ Telephone: \_\_\_\_\_  
Location: \_\_\_\_\_ Fax: \_\_\_\_\_

Engine Manufacturer: \_\_\_\_\_ Model: \_\_\_\_\_ Year: \_\_\_\_\_  
Displacement: \_\_\_\_\_ Cubic In. ☐ Liters ☐ (check one) # of Cylinders: \_\_\_\_\_  
Configuration: Inline ☐ Vee ☐ (check one) 4-Cycle ☐ 2-Cycle ☐ (check one)  
Rated Speed: \_\_\_\_\_ rpm Rated Power \_\_\_\_\_ BHP ☐ KW ☐ (check one)  
Aspiration: Normal ☐ Turbocharged ☐ Supercharged ☐ (check one)  
Stoichiometric ☐ Lean Burn ☐ (check one)  
AFC Installed: Yes ☐ No ☐ (check one) Type: \_\_\_\_\_ Ignition Type: \_\_\_\_\_  
Carburetor: Model # \_\_\_\_\_ SAE Flange Size: \_\_\_\_\_ Throttle Body Bolt Ctr. \_\_\_\_\_

Fuel Type: NG ☐ LPG ☐ Digester ☐ Land Fill ☐ (check one) BTU: \_\_\_\_\_  
Known Contaminants: \_\_\_\_\_  
Minimum Fuel Pressure @ Carburetor (Engine @ Full Load): \_\_\_\_\_  
Minimum Fuel Pressure @ Carburetor (Engine not Running): \_\_\_\_\_  
Engine Location: \_\_\_\_\_  
Engine Application: Generator ☐ Compressor ☐ Pump ☐ Other ☐ (check one)

NOTES: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### IMPCO:

Carburetor: \_\_\_\_\_ Gas Conversion Kit: \_\_\_\_\_  
Mixer: \_\_\_\_\_ Pressure Regulator: \_\_\_\_\_  
Gas Inlet Module: \_\_\_\_\_ Pressure Sub-Regulator: \_\_\_\_\_  
Mixture Outlet Module (Throttle Body): \_\_\_\_\_ Accessories/Options: \_\_\_\_\_  
Air Inlet Module (Air Horn) Adapters: \_\_\_\_\_

Written By: \_\_\_\_\_

## Test Equipment/Tools

### U-Tube Manometer:

The U-tube manometer is a highly accurate, yet very convenient and easy to use pressure measurement tool. It is designed to measure slight positive and negative pressures. It can and should be used to measure or calibrate other face type gauges.

Taking a reading:

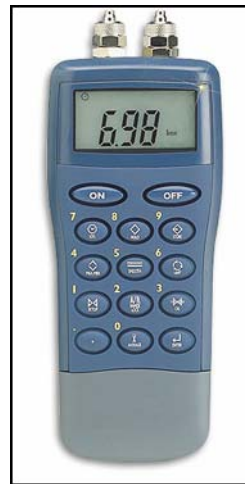
- Connect the manometer to the source of pressure, vacuum or differential pressure according to the manufacturer's instructions.
- While pressure is applied, add the number of inches one column travels up to the amount the other column travels down.

### Electronic Manometer (Figure #45):

Electronic, digital manometers are very accurate, but more costly than a U-tube manometer. They support a wide array of functions making them extremely versatile. Follow the manufacturer's instructions for use on these types of meters.



**Figure #44**

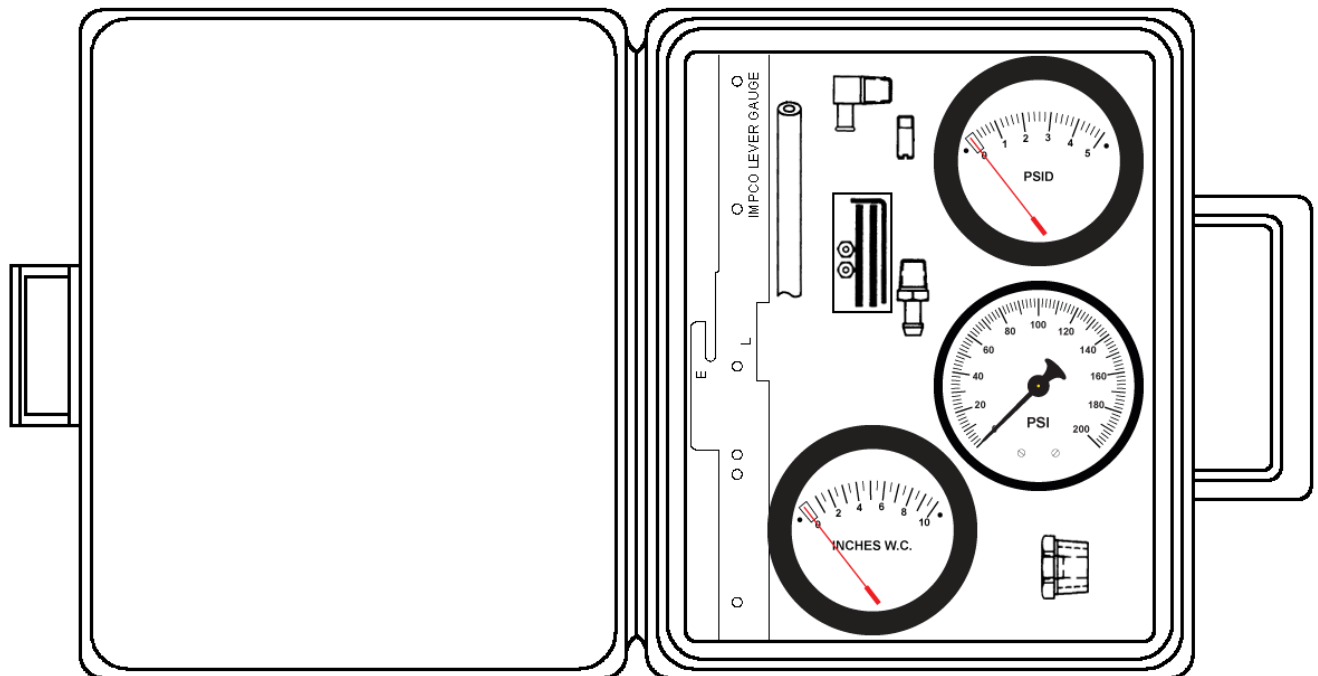


**Figure #45**

## IMPCO ITK-1 Test Kit:

The IMPCO ITK-1 test kit is designed for testing and troubleshooting IMPCO gaseous fuel systems. The kit contains the following:

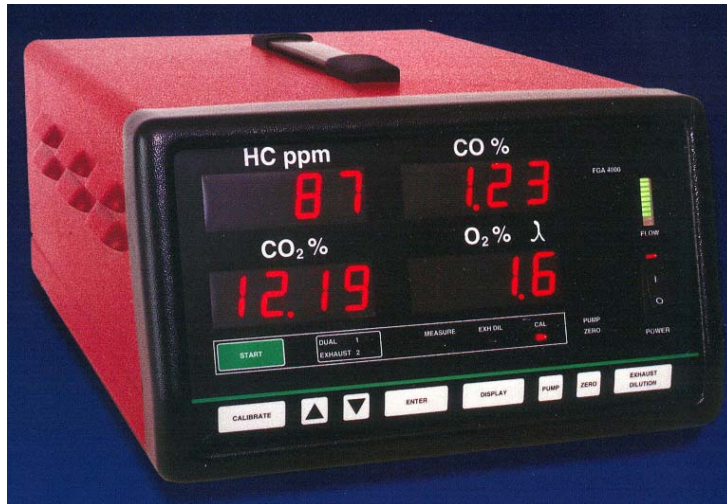
- **0-200 PSI Gauge:** For measuring fuel container pressure or (on dual fuel systems) it may be used to measure gasoline fuel system pressure.
- **0-5 PSI Gauge:** For measuring IMPCO pressure regulator, primary pressure.
- **0-10" H<sub>2</sub>O Column Gauge:** For measuring IMPCO pressure regulator, secondary pressure.
- **G2-2 Lever Gauge:** For correct adjustment of the IMPCO pressure regulator, secondary lever.
- **Assorted Fittings**
- **Hose**
- **Instructions**



**Figure #46**

### Gas Exhaust Gas Analyzer:

IMPCO recommends the use of a 5-gas exhaust gas analyzer (such as the Infrared Industries FGA-5000). This is the only empirical way to ensure adherence to emission requirements.



**Figure #47**

### Digital Volt and Ohm Meter (DVOM):

The DVOM is a standard and essential diagnostic tool. It is used for measuring various types of electrical signals. The use of a Fluke™ or equivalent DVOM is highly recommended for their reliability and accuracy. Some important characteristics of a DVOM are:

- High-impedance (safe for sensitive, solid state circuits)
- Very accurate
- Filtered, adjustable sample rates.



**Figure #48**



## Conversion Factors

### Powers of Ten:

For simplification, the following table of conversion factors is expressed entirely as multiplication of a known unit and quantity, to transpose it to a desired equivalent unit and quantity.

The powers of ten are used to reduce the length of unwieldy numbers, and to assist in the proper placement of the decimal point in the result.

Examples:

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
15 Cubic Centimeters	$6.10 \times 10^{-2}$	Cubic Inches

$$15 \times 6.1 \times 10^{-2} = \text{cubic inches}$$

$$91.5 \times 10^{-2} = 0.915 \text{ cubic inches}$$

The power of  $10^{-2}$  indicates moving the decimal point two places to the left (or minus side) of the result.

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
15 Cubic Feet	$2.832 \times 10^4$	Cubic Centimeters

$$15 \times 2.832 \times 10^4 = \text{cubic centimeters}$$

$$42.48 \times 10^4 = 424,800 \text{ cubic centimeters}$$

The power of the  $10^4$  indicates moving the decimal point 4 places to the right (or plus side) of the results.

## Conversion Table

Multiply	By	To Obtain
Abamperes	10	Amperes
Abamperes	3x10 <sup>-10</sup>	Statamperes
Abamperes per sq cm	64.52	Amperes per sq inch
Abampere-turns	10	Ampere-turns
Abampere-turns	12.57	Gilberts
Abampere-turns per cm	25.4	Ampere-turns per inch
Abcoulombs	10	Coulombs
Abcoulombs	3x10 <sup>10</sup>	Statcoulombs
Abcoulombs per sq cm	64.52	Coulombs per sq inch
Abfarads	109	Farads
Abfarads	9x10 <sup>20</sup>	Statfarads
Abhenries	39364	Henries
Abhenries	39361	Millihenries
Abhenries	1/9x10 <sup>-20</sup>	Stathenries
Abmhos per cm cube	1.662x10 <sup>2</sup>	Mhos per mil foot
Abmhos per cm cube	103	Megmhos per cm cube
Abohms	39370	Megohms
Abohms	39358	microhms
Abohms	39364	Ohms
Abohms	1/9x10 <sup>-20</sup>	Statohms
Abohms per cm cube	39358	Micohms per cm cube
Abohms per cm cube	6.015x10 <sup>-3</sup>	Ohms per mil foot
Abvolts	1/3x10 <sup>-10</sup>	Statvolts
Abvolts	39363	Volts
Acre-feet	43560	Cubic feet
Acre-feet	3.259x10 <sup>5</sup>	Gallons
Acres	43560	Square feet
Acres	4047	Square meters
Acres	1.562x10 <sup>-3</sup>	Square miles
Acres	5645.38	Square varas
Acres	4840	Square yards
Amperes	39092	Abamperes
Amperes per sq cm	6.453	Amperes per sq inch
Amperes per sq inch	0.0155	Abamperes per sq cm
Amperes per sq inch	0.155	Amperes per sq cm
Amperes per sq inch	4.650x10 <sup>8</sup>	Statamperes per sq cm
Ampere-turns	39092	Abampere-turns
Ampere-turns	1.257	Gilberts
Ampere-turns per cm	2.54	Ampere-turns per inch
Ampere-turns per inch	0.03937	Abampere-turns per cm
Ampere-turns per inch	0.3937	Ampere-turns per cm
Ampere-turns per inch	0.495	Gilberts per cm
Amp-weber/meter	1	Newton
Angstrom unit	39363	Centimeters
Ares	0.02471	Acres

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Ares	100	Square meters
Atmospheres	33.9	Feet of water
Atmospheres	10.333	Kg per sq meter
Atmospheres	14.7	Pounds per sq inch
Atmospheres	1.058	Tons per sq foot
Atmospheres	76	Cms of mercury
Atmospheres	29.92	Inches of mercury
Average noon sunlight on 1 sq meter	Approx. 1	Kilowatt-hours
Bar	14.5	Pounds per sq inch
Board-feet	144	Cubic inches
British thermal units	0.253	Kilogram-calories
British thermal units	777.5	Foot-pounds
British thermal units	3.927x10 <sup>-4</sup>	Horsepower-hours
British thermal units	1054	Joules
British thermal units	107.5	Kilogram-meters
British thermal units	2.928x10 <sup>-4</sup>	Kilowatt-hours
BTU per cu ft	8.899	Kg-cal per cu meter
BTU per min	12.96	Foot-pounds per sec
BTU per min	0.02356	Horsepower
BTU per min	0.01757	Kilowatts
BTU per min	17.57	Watts
BTU per pound	0.5556	Kg-cal per kg
BTU per sq ft	2.712	Kg-cal per sq meter
BTU per sq ft per min	0.122	Watts per sq inch
BTU/(hr)(sq ft)(deg F)	4.88	Kg-cal/(hr)(sq m)(deg C)
Bushels	1.244	Cubic feet
Bushels	2150	Cubic inches
Bushels	0.03524	Cubic meters
Bushels	4	Pecks
Bushels	64	Pints (dry)
Bushels	32	Quarts (dry)
Calorie	0.239	Joule
Centares	1	Sq meters
Centigrams	0.01	Grams
Centiliters	0.01	Liters
Centimeter-dynes	1.020x10 <sup>-3</sup>	Centimeter-grams
Centimeter-dynes	1.020x10 <sup>-8</sup>	Meter-kilograms
Centimeter-dynes	7.376x10 <sup>-8</sup>	Pound-feet
Centimeter-grams	980.7	Centimeter-dynes
Centimeter-grams	39360	Meter-kilograms
Centimeter-grams	7.233x10 <sup>-5</sup>	Pound-feet
Centimeters	0.3937	Inches
Centimeters	0.01	Meters
Centimeters	393.7	Mils
Centimeters	10	Millimeters
Centimeters	108	Angstrom unit
Centimeters of mercury	0.01316	Atmospheres
Centimeters of mercury	0.4461	Feet of water

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Centimeters of mercury	136	Kg per sq meter
Centimeters of mercury	27.85	Pounds per sq foot
Centimeters of mercury	0.1924	Pounds per sq inch
Centimeters per second	1.969	Feet per minute
Centimeters per second	0.03281	Feet per second
Centimeters per second	0.036	Kilometers per hour
Centimeters per second	0.6	Meters per minute
Centimeters per second	0.02237	Miles per hour
Centimeters per second	3.278x10-4	Miles per minute
Circular mils	5.067x10-4	Sq centimeters
Circular mils	7.854x10-7	Sq inches
Circular mils	0.7854	Sq mils
Cm per sec per sec	0.03281	Feet per sec per sec
Cm per sec per sec	0.036	Km per hour per sec
Cm per sec per sec	0.02237	Miles per hour per sec
Cords	128	Cubic feet
Coulombs	39092	Abcoulombs
Coulombs	3x108	Statcoulombs
Coulombs per sq inch	0.0155	Abcoulombs per sq cm
Coulombs per sq inch	0.155	Coulombs per sq cm
Coulombs per sq inch	4.650x10-5	Statcoulombs per sq cm
Cubic centimeters	3.531x10-5	Cubic feet
Cubic centimeters	6.10x10-2	Cubic inches
Cubic centimeters	39361	Cubic meters
Cubic centimeters	1.308x10-6	Cubic yards
Cubic centimeters	2.642x10-4	Gallons
Cubic centimeters	39358	Liters
Cubic centimeters	2.113x10-3	Pints (liq)
Cubic centimeters	1.057x10-3	Quarts (liq)
Cubic feet	2.832x104	Cubic cms
Cubic feet	1728	Cubic inches
Cubic feet	0.02832	Cubic meters
Cubic feet	0.03704	Cubic yards
Cubic feet	7.481	Gallons
Cubic feet	28.32	Liters
Cubic feet	59.84	Pints (liq)
Cubic feet	29.92	Quarts (liq)
Cubic ft per minute	472	Cubic cm per sec
Cubic ft per minute	0.1247	Gallons per sec
Cubic ft per minute	0.472	Liters per sec
Cubic ft per minute	62.4	Lb of water per min
Cubic inches	4.329x10-3	Gallons
Cubic inches	1.639x10-2	Liters
Cubic inches	0.03463	Pints (liq)
Cubic inches	0.01732	Quarts (liq)
Cubic inches	16.39	Cubic centimeters
Cubic inches	5.787x10-4	Cubic feet
Cubic inches	1.639x10-5	Cubic meters

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Cubic inches	2.143x105	Cubic yards
Cubic meters	106	Cubic centimeters
Cubic meters	35.31	Cubic feet
Cubic meters	61023	Cubic inches
Cubic meters	1308	Cubic yards
Cubic meters	264.2	Gallons
Cubic meters	103	Liters
Cubic meters	2113	Pints (liq)
Cubic meters	1057	Quarts (liq)
Cubic yards	7.646x105	Cubic centimeters
Cubic yards	27	Cubic feet
Cubic yards	46656	Cubic inches
Cubic yards	0.7646	Cubic meters
Cubic yards	202	Gallons
Cubic yards	764.6	Liters
Cubic yards	1616	Pints (liq)
Cubic yards	807.9	Quarts (liq)
Cubic yards per min	0.45	Cubic ft per sec
Cubic yards per min	3.367	Gallons per sec
Cubic yards per min	12.74	Liters per sec
Days	24	Hours
Days	1440	Minutes
Days	86400	Seconds
Decameters	10	Meters
Decigrams	0.1	Grams
Deciliters	0.1	Liters
Decimeters	0.1	Meters
Degrees (angle)	60	Minutes
Degrees (angle)	0.01745	Radians
Degrees (angle)	3600	Seconds
Degrees per sec	0.01745	Radians per sec
Degrees per sec	0.1667	Revolutions per min
Degrees per sec	0.002778	Revolutions per sec
Dekagrams	10	Grams
Dekaliters	10	Liters
Diameter squared	0.7854	Area of a circle
Diameter squared	3.1416	Area of a sphere
Drams	1.772	Grams
Drams	0.0625	Ounces
Dynes	39360	Newtons
Dynes	1.020x10-3	Grams
Dynes	7.233x10-5	Poundals
Dynes	2.248x10-6	Pounds
Dynes per sq cm	1	Bars
Ergs	9.48x10-11	BTUs
Ergs	1	Dyne-centimeters
Ergs	7.376x10-8	Foot-pounds
Ergs	1.020x10-3	Gram-centimeters

Multiply	By	To Obtain
Ergs	39362	Joules
Ergs	$2.39 \times 10^{-11}$	Kilogram-calories
Ergs	$1.020 \times 10^{-8}$	Kilogram-meters
Ergs per sec	$5.692 \times 10^{-9}$	BTU per min
Ergs per sec	$4.426 \times 10^{-6}$	Foot-pounds per min
Ergs per sec	$7.376 \times 10^{-8}$	Foot-pounds per sec
Ergs per sec	$1.341 \times 10^{-10}$	Horsepower
Ergs per sec	$1.434 \times 10^{-9}$	Kg-calories per min
Ergs per sec	39365	Kilowatts
Farads	39364	Abfarads
Farads	106	Microfarads
Farads	$9 \times 10^{-11}$	Statfarads
Fathoms	6	Feet
Feet	30.48	Centimeters
Feet	12	Inches
Feet	0.3048	Meters
Feet	0.36	Varas
Feet	39085	Yards
Feet of water	0.0295	Atmospheres
Feet of water	0.8826	Inches of mercury
Feet of water	304.8	Kg per sq meter
Feet of water	62.43	Pounds per sq ft
Feet of water	0.4335	Pounds per sq inch
Feet per 100 feet	1	Per cent grade
Feet per min	0.508	Centimeters per sec
Feet per min	0.01667	Feet per sec
Feet per min	0.01829	Kilometers per hr
Feet per min	0.3048	Meters per min
Feet per min	0.01136	Miles per hr
Feet per sec	30.48	Centimeters per sec
Feet per sec	1.097	Kilometers per hr
Feet per sec	18.29	Meters per min
Feet per sec	0.6818	Miles per hr
Feet per sec	0.01136	Miles per min
Feet per sec per sec	30.48	Cm per sec per sec
Feet per sec per sec	1.097	Cm per sec per sec
Feet per sec per sec	0.3048	Meters per sec per sec
Feet per sec per sec	0.6818	Miles per hr per sec
Foot-pounds	0.1383	Kilogram-meters
Foot-pounds	$3.766 \times 10^{-7}$	Kilowatt-hours
Foot-pounds	$1.286 \times 10^{-3}$	British Thermal Units
Foot-pounds	$1.356 \times 10^7$	Ergs
Foot-pounds	$5.050 \times 10^{-7}$	Horsepower-hrs
Foot-pounds	1.356	Joules
Foot-pounds	$3.241 \times 10^{-4}$	Kilogram-calories
Foot-pounds per min	$1.286 \times 10^{-3}$	BTU per min
Foot-pounds per min	0.01667	Foot-pounds per sec
Foot-pounds per min	$3.030 \times 10^{-5}$	Horsepower

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Foot-pounds per min	3.241x10-4	Kg-calories per min
Foot-pounds per min	2.260x10-5	Kilowatts
Foot-pounds per sec	7.717x10-2	BTU per min
Foot-pounds per sec	1.818x10-3	Horsepower
Foot-pounds per sec	1.945x10-2	Kg-calories per min
Foot-pounds per sec	1.356x10-3	Kilowatts
Furlongs	40	Rods
Gallons	3785	Cubic centimeters
Gallons	0.1337	Cubic feet
Gallons	231	Cubic inches
Gallons	3.785x10-3	Cubic meters
Gallons	4.951x10-3	Cubic yards
Gallons	3.785	Liters
Gallons	8	Pints (liq)
Gallons	4	Quarts (liq)
Gallons per min	2.228x10-3	Cubic feet per sec
Gallons per min	0.06308	Liters per sec
Gausses	6.452	Lines per sq inch
Gilberts	0.07958	Abampere-turns
Gilberts	0.7958	Ampere-turns
Gilberts per centimeter	2.021	Ampere-turns per inch
Gills	0.1183	Liters
Gills	0.25	Pints (liq)
Grains (troy)	1	Grains (av)
Grains (troy)	0.0648	Grams
Grains (troy)	0.04167	Pennyweights (troy)
Grains/US gallon	17.118	Parts per million
Gram-calories	3.968x10-3	BTUs
Gram-centimeters	9.302x10-8	BTUs
Gram-centimeters	980.7	Ergs
Gram-centimeters	7.233x10-5	Foot-pounds
Gram-centimeters	9.807x10-5	Joules
Gram-centimeters	2.344x10-8	Kilogram-calories
Gram-centimeters	39360	Kilogram-meters
Grams	980.7	Dynes
Grams	15.43	Grains (troy)
Grams	39358	Kilograms
Grams	103	Milligrams
Grams	0.03527	Ounces
Grams	0.03215	Ounces (troy)
Grams	0.07093	Poundals
Grams	2.205x10-3	Pounds
Grams per cm	5.600x10-3	Pounds per inch
Grams per cu cm	62.43	Pounds per cu foot
Grams per cu cm	0.03613	Pounds per cu inch
Grams per cu cm	3.405x10-7	Pounds per mil-foot
Hectares	2.471	Acres
Hectares	1.076x105	Sq feet

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Hectograms	100	Grams
Hectoliters	100	Liters
Hectometers	100	Meters
Hectowatts	100	Watts
Hemispheres (solid angle)	0.5	sphere
Hemispheres (solid angle)	4	Spherical right angles
Hemispheres (solid angle)	6.283	Steradians
Henries	109	Abhenries
Henries	103	Millihenries
Henries	1/9x10 <sup>-11</sup>	Stathenries
Horsepower	42.44	BTU per min
Horsepower	33000	Foot-pounds per min
Horsepower	550	Foot-pounds per sec
Horsepower	1.014	Horsepower (metric)
Horsepower	10.7	Kg-calories per min
Horsepower	0.7457	Kilowatts
Horsepower	745.7	Watts
Horsepower (boiler)	33520	BTU per hr
Horsepower (boiler)	9804	Kilowatts
Horsepower-hours	2547	BTUs
Horsepower-hours	1.98x10 <sup>6</sup>	Foot-pounds
Horsepower-hours	2.684x10 <sup>6</sup>	Joules
Horsepower-hours	641.7	Kilogram-calories
Horsepower-hours	2.737x10 <sup>5</sup>	Kilogram-meters
Horsepower-hours	0.7457	Kilowatt-hours
Hours	60	Minutes
Hours	3600	Seconds
Inches	2540	Centimeters
Inches	103	Mils
Inches	0.03	Varas
Inches of Hg	1.133	Feet of water
Inches of Hg	345.3	Kg per sq meter
Inches of Hg	70.73	Pounds per sq ft
Inches of Hg	0.4912	Pounds per sq in
Inches of mercury (Hg)	0.03342	Atmospheres
Inches of water	5.204	Pounds per sq foot
Inches of water	0.03613	Pounds per sq in (PSI)
Inches of water	0.002458	Atmospheres
Inches of water	0.07355	Inches of mercury
Inches of water	25.4	Kg per sq meter
Inches of water	0.5781	Ounces per sq inch
Joule	4.184	Calorie
Joule per sec	1	Watts
Joule/sq amp sec	1	Ohm
Joules	9.486x10 <sup>-4</sup>	BTUs
Joules	107	Ergs
Joules	0.7376	Foot-pounds
Joules	2.390x10 <sup>-4</sup>	Kilogram-calories



<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Joules	0.102	Kilogram-meters
Joules	2.778x10 <sup>-4</sup>	Watt-hours
Joules	1	Newton meters
Joules	1	Watt-sec
Joules	1	Volt-coulomb
Kg per cu meter	39358	Grams per cu cm
Kg per cu meter	0.06243	Pounds per cu foot
Kg per cu meter	3.613x10 <sup>-5</sup>	Pounds per cu inch
Kg per cu meter	3.405x10 <sup>-10</sup>	Pounds per mil-foot
Kg per meter	0.672	Pounds per foot
Kg per sq meter	9.678x10 <sup>-5</sup>	atmospheres
Kg per sq meter	98.07	Bars
Kg per sq meter	3.281x10 <sup>-3</sup>	Feet of water
Kg per sq meter	2.896x10 <sup>-3</sup>	Inches of mercury
Kg per sq meter	0.2048	Pounds per sq foot
Kg per sq meter	1.422x10 <sup>-3</sup>	Pounds per sq inch
Kg per sq millimeter	106	Kg per sq meter
Kg-cal/cu meter	0.1124	BTU per cu foot
Kg-cal/kg	1.8	BTU per pound
Kg-cal/sq meter	0.3688	BTU per sq foot
Kg-calories per min	51.43	Foot-pounds per sec
Kg-calories per min	0.09351	Horsepower
Kg-calories per min	0.06972	Kilowatts
Kg-cm squared	2.373x10 <sup>-3</sup>	Pounds-feet squared
Kg-cm squared	0.3417	Pounds-inch squared
Kg-meter/sq second	1	Newton
Kilogram-calories	3.968	BTUs
Kilogram-calories	3086	Foot-pounds
Kilogram-calories	1.556x10 <sup>-3</sup>	Horsepower-hours
Kilogram-calories	4183	Joules
Kilogram-calories	426.6	Kilogram-meters
Kilogram-calories	1.162x10 <sup>-3</sup>	Kilowatt-hours
Kilogram-meters	9.302x10 <sup>-3</sup>	BTUs
Kilogram-meters	9.807x10 <sup>7</sup>	Ergs
Kilogram-meters	7.233	Foot-pounds
Kilogram-meters	9.807	Joules
Kilogram-meters	2.344x10 <sup>-3</sup>	Kilogram-calories
Kilogram-meters	2.724x10 <sup>-6</sup>	Kilowatt-hours
Kilograms	980665	Dynes
Kilograms	103	Grams
Kilograms	70.93	Poundals
Kilograms	2.2046	Pounds
Kilograms	1.102x10 <sup>-3</sup>	Tons (short)
Kilolines	103	Maxwells
Kiloliters	103	Liters
Kilometers	105	Centimeters
Kilometers	3281	Feet
Kilometers	103	Meters

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Kilometers	0.6214	Miles
Kilometers	1093.6	Yards
Kilometers per hr	27.78	Centimeters per sec
Kilometers per hr	54.68	Feet per min
Kilometers per hr	0.9113	Feet per sec
Kilometers per hr	0.5396	Knots
Kilometers per hr	16.67	Meters per min
Kilometers per hr	0.6214	Miles per hr
Kilometers per min	60	Kilometers per hr
Kilowatt-hours	Approx. 1	Average noon sunlight on 1 sq meter
Kilowatt-hours	3415	BTUs
Kilowatt-hours	2.655x106	Foot-pounds
Kilowatt-hours	1.341	Horsepower-hours
Kilowatt-hours	3.6x105	Joules
Kilowatt-hours	860.5	Kilogram-calories
Kilowatt-hours	3.67x105	Kilogram-meters
Kilowatts	56.92	BTU per min
Kilowatts	4.425x104	Foot-pounds per min
Kilowatts	737.6	Foot-pounds per sec
Kilowatts	1.341	Horsepower
Kilowatts	14.34	Kg-calories per min
Kilowatts	103	Watts
Km per hr per sec	27.78	Cm per sec per sec
Km per hr per sec	0.9113	Ft per sec per sec
Km per hr per sec	0.2778	Meters per sec per sec
Km per hr per sec	0.6214	Miles per hr per sec
Knots	6080	Feet per hr
Knots	1.853	Kilometers per hr
Knots	1.152	Miles per hr
Knots	2027	Yards per hr
Lines per sq cm	1	Gaus
Lines per sq inch	0.155	Gaus
Links (engineer's)	12	Inches
Links (surveyor's)	7.92	Inches
Liters	0.03531	Cubic feet
Liters	61.02	Cubic inches (=dm3)
Liters	39358	Cubic meters
Liters	1.308x10-3	Cubic yards
Liters	0.2642	Gallons
Liters	2.113	Pints (liq)
Liters	1.057	Quarts (liq)
Liters	103	Cubic cm
Liters per min	5.886x10-4	Cubic ft per sec
Liters per min	4.403x10-3	Gallons per sec
Log/e N or ln N	0.4343	Log10 N
Log10 N	2.303	Log/e N or ln N
Lumens per sq ft	1	Foot-candles
Maxwells	39358	Kilolines

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Megalines	106	Maxwells
Megmhos per cm cube	39358	Abmhos per cm cube
Megmhos per cm cube	2.54	Megmhos per in cube
Megmhos per cm cube	0.1662	Mhos per mil ft
Megmhos per inch cube	0.3937	Megmhos per cm cube
Megohms	106	Ohms
Meter-kilograms	9.807x107	Centimeter-dynes
Meter-kilograms	105	Centimeter-grams
Meter-kilograms	7.233	Pound-feet
Meters	100	Centimeters
Meters	3.2808	Feet
Meters	39.37	Inches
Meters	39358	Kilometers
Meters	103	Millimeters
Meters	1.0936	Yards
Meters per min	1.667	Centimeters per sec
Meters per min	3.281	Feet per min
Meters per min	0.05468	Feet per sec
Meters per min	0.06	Kilometers per hr
Meters per min	0.03728	Miles per hr
Meters per sec	1968	Feet per min
Meters per sec	3.281	Feet per sec
Meters per sec	6	Kilometers per hr
Meters per sec	0.06	Kilometers per min
Meters per sec	2.237	Miles per hr
Meters per sec	0.03728	Miles per min
Meters per sec per sec	3.281	Feet per sec per sec
Meters per sec per sec	3.6	Km per hr per sec
Meters per sec per sec	2.237	Miles per hr per sec
Mhos per mil foot	6.015x10-3	Abmhos per cm cube
Mhos per mil foot	6.015	Megmhos per cm cube
Mhos per mil foot	15.28	Megmhos per in cube
Microbars	9.870x10-7	Atmospheres
Microbars	1	Dynes per sq cm
Microbars	0.0102	Kg per sq meter
Microbars	2.089x10-3	Pounds per sq foot
Microbars	1.450x10-5	Pounds per sq inch
Microfarads	39370	Abfarads
Microfarads	39361	Farads
Microfarads	9x105	Statfarads
Micrograms	39361	Grams
Microhms	103	Abohms
Microhms	39367	Megohms
Microhms	39361	Ohms
Microhms	1/9x10-17	Statohms
Microhms per cubic cm	103	Abohms per cubic cm
Microhms per cubic cm	0.3937	Microhms per cubic in
Microhms per cubic cm	6.015	Ohms per mil foot

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Microhms per cubic in	2.54	Microhms per cubic cm
Microliters	39361	Liters
Microns	39361	Meters
Miles	1.609x10 <sup>5</sup>	Centimeters
Miles	5280	Feet
Miles	1.6093	Kilometers
Miles	1760	Yards
Miles	1900.8	Varas
Miles per hr	44.7	Centimeters per sec
Miles per hr	88	Feet per min
Miles per hr	1.467	Feet per sec
Miles per hr	1.6093	Kilometers per hr
Miles per hr	0.8684	Knots
Miles per hr	26.82	Meters per min
Miles per hr per sec	44.7	Cm per sec per sec
Miles per hr per sec	1.467	Feet per sec per sec
Miles per hr per sec	1.6093	Km per hr per sec
Miles per hr per sec	0.447	Meters per sec per sec
Miles per min	2682	Centimeters per sec
Miles per min	88	Feet per sec
Miles per min	1.6093	Kilometers per min
Miles per min	60	Miles per hr
Millibars	14.5x10 <sup>-3</sup>	Pounds per sq inch
Milligrams	39358	Grams
Millihenries	106	Abhenries
Millihenries	1/9x10 <sup>-14</sup>	Stathenries
Milliliters	39358	Liters
Millimeters	0.1	Centimeters
Millimeters	0.03937	Inches
Millimeters	39.37	Mils
Mils	39358	Inches
Mils	0.00254	Centimeters
Miner's inches	1.5	Cubic ft per min
Minutes (angle)	2.909x10 <sup>-4</sup>	Radian
Minutes (angle)	60	Seconds (angle)
Months	30.42	Days
Months	730	Hours
Months	43800	Minutes
Months	2.628x10 <sup>6</sup>	Seconds
Myriagrams	10	Kilograms
Myriameters	10	Kilometers
Myriawatts	10	Kilowatts
Newton	1	Amp-weber/meter
Newton	1	Kg-meter/sq sec
Newton meters	1	Joules
Newton-meter/amp	1	Weber
Newtons	1.355	Pound-feet
Newtons	105	Dynes

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Ohm	1	Joule/sq amp sec
Ohms	109	Abohms
Ohms	39361	Megohms
Ohms	106	Microhms
Ohms	1/9x10 <sup>-11</sup>	Statohms
Ohms per mil foot	166.2	Abohms per cubic cm
Ohms per mil foot	0.1662	Microhms per cubic cm
Ohms per mil foot	0.06524	Microhms per cubic in
Ounces	8	Drams
Ounces	437.5	Grains
Ounces	28.35	Grams
<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Ounces	0.0625	Pounds
Ounces (fluid)	1.805	Cubic inches
Ounces (fluid)	0.02957	Liters
Ounces (troy)	480	Grains (troy)
Ounces (troy)	31.1	Grams
Ounces (troy)	20	Pennyweights (troy)
Ounces (troy)	0.08333	Pounds (troy)
Ounces per sq inch	0.0625	Pounds per sq inch
Parts per million	0.0584	Grains/US gallon
Pennyweights (troy)	24	Grains (troy)
Pennyweights (troy)	1.555	Grams
Pennyweights (troy)	0.05	Ounces (troy)
Perches (masonry)	24.75	Cubic feet
Pints (dry)	33.6	Cubic inches
Pints (liq)	28.87	Cubic inches
Poundals	13826	Dynes
Poundals	14.1	Grams
Poundals	0.03108	Pounds
Pound-feet	1.356x10 <sup>7</sup>	Centimeter-dynes
Pound-feet	13825	Centimeter-grams
Pound-feet	0.1383	Meter-kilograms
Pound-feet	0.738	Newtons
Pounds	444823	Dynes
Pounds	7000	Grains
Pounds	453.6	Grams
Pounds	16	Ounces
Pounds	32.17	Poundals
Pounds (troy)	0.8229	Pounds (av)
Pounds of water	0.01602	Cubic feet
Pounds of water	27.68	Cubic inches
Pounds of water	0.1198	Gallons
Pounds of water per min	2.669x10 <sup>-4</sup>	Cubic ft per sec
Pounds per cubic ft	0.01602	Grams per cubic cm
Pounds per cubic ft	16.02	Kg per cubic meter
Pounds per cubic ft	5.787x10 <sup>-4</sup>	Pounds per cubic in
Pounds per cubic ft	5.456x10 <sup>-9</sup>	Pounds per mil foot

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Pounds per cubic in	27.68	Grams per cubic cm
Pounds per cubic in	2.768x104	Kg per cubic meter
Pounds per cubic in	1728	Pounds per cubic ft
Pounds per cubic in	9.425x10-6	Pounds per mil foot
Pounds per ft	1.488	Kg per meter
Pounds per in	178.6	Grams per cm
Pounds per mil foot	2.306x106	Grams per cubic cm
Pounds per sq ft	0.01602	Feet of water
Pounds per sq ft	4.882	Kg per sq meter
Pounds per sq ft	6.944x10-3	Pounds per sq in
Pounds per sq in (PSI)	0.06804	Atmospheres
Pounds-ft squared	421.3	Kg-cm squared
Pounds-ft squared	144	Pounds-in squared
Pounds-inches squared	2.926	Kg-cm squared
Pounds-inches squared	6.945x10-3	Pounds-ft squared
PSI	2.307	Feet of water
PSI	2.036	Inches of mercury
PSI	703.1	Kg per sq meter
PSI	144	Pounds per sq ft
Quadrants (angle)	90	Degrees
Quadrants (angle)	5400	Minutes
Quadrants (angle)	1.571	Radians
Quarts (dry)	67.2	Cubic inches
Quarts (liq)	57.75	Cubic inches
Quintals	100	Pounds
Quires	25	Sheets
Radians	57.3	Degrees
Radians	3438	Minutes

## Approximate Heat Content of Petroleum Products

Table is in millions of BTUs per barrel (42 gallons) (High heat content).

Energy Source	Energy Content	Energy Source	Energy Content
Asphalt	6.636	Isobutane	3.974
Aviation Gasoline	5.048	Jet Fuel (Kerosene Type)	5.670
Butane	4.326	Jet Fuel (Naphtha Type)	5.355
Butane/Propane (60/40)	4.130	Kerosene	5.670
Crude Oil	5.800	Motor Gasoline (Conventional)	5.253
Distillate Fuel Oil	5.825	Motor Gasoline (Oxygenated or Reformulated)	5.150
Ethane	3.082	Motor Gasoline (Fuel Ethanol)	3.539
Ethane/Propane (70/30)	3.308	Propane	3.836

## Correction Table for Altitudes

(Standard Atmospheric Pressure @ Sea Level is 29.92" Hg)

Altitude (in feet)	Deduct from 29.92" Hg	Altitude (in feet)	Deduct from 29.92" Hg
100	0.12"	2600	2.82"
250	0.29"	2700	2.93"
500	0.57"	2800	3.03"
750	0.85"	2900	3.13"
1000	1.12"	3000	3.24"
1250	1.39"	3100	3.34"
1500	1.66"	3200	3.44"
1750	1.93"	3300	3.54"
2000	2.20"	3400	3.64"
2100	2.30"	3500	3.74"
2200	2.41"	4000	4.24"
2300	2.51"	4500	4.72"
2400	2.62"	5000	5.20"
2500	2.72"	5500	5.67"

These values can be deducted directly when reading an intake manifold depression (vacuum) gauge at one of the given altitudes on a normally aspirated engine. An intake manifold vacuum gauge will read approximately 20.92" Hg @ sea level on an unloaded engine. Since the 9" Hg differential between atmospheric pressure and the intake manifold does not change with altitude, the values above can be deducted directly from the gauge.

Example:

The manifold depression for an engine operating at 3000 feet would be the standard 29.92" Hg minus 9" Hg differential with an additional deduction of 3.24" Hg  $= (29.92" - 9") - 3.24" = 17.68" \text{ Hg}$ ; or  $20.92" \text{ Hg} - 3.24" = 17.68" \text{ Hg}$





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